Protective Effect of Horsetail (*Equisetum arvense, L.*) Against Food Azo Dye Tartrazine toxicity on some biochemical parameters and antioxidants of Male Rats: Role of Oxidative Stress

[1]Rania Shams El deen Fakher Eldeen, [2] samah A. Elsemelawy
[1]Home Economics Dept., Faculty of Specific Education, Tanta University .Egypt.
[2]Home Economics Dept., Faculty of Specific Education, Tanta University .Egypt.

ABSTRACT

Background: Nowadays, there is a growing interest in medicinal plant usage. Horsetail (*Equisetum arvense*, L.) plant family *Equisetaceae* has many uses in traditional medicine and possesses several pharmacological effects, mostly antioxidant effects. Tartrazine (TZ) is an organic azo dyes widely used in coloring food additives, drugs and cosmetics. It can trigger oxidative stress which consequently generates metabolic disorders as hepatic and renal toxicity. Therefore, this study was designed to evaluate the protective properties of horsetail against TZ mediated oxidative stress in rats. **Material and methods:** forty-two rats were randomly classified into six groups (7 rats each). The first group (G1) kept as a negative control, the other five groups gave oral tartrazine-intoxicated, 300 mg /kg b.wt. /day. One group served as a positive control (G2), while the others TZ groups treated with horsetail powder and extract as follow: G3 10% Horsetail powder / kg/ diet/day, G4: 10 mg Horsetail extract /kg b.wt., G 5: 20% Horsetail powder / kg/ diet/day and G 6: 20 mg Horsetail extract /kg b.wt. **Results** showed that administration of Horsetail (powder and extract) at all dosages significantly improved, rats body weight gain percentage, HB, PCV, liver functions (ALT, AST and ALP) and kidney functions (creatinine and uric acid) as compared to TZ group. These were associated with significant increment of plasma antioxidants biomarkers GST, SOD and CAT and decrement of NO oxidative stress biomarker, also in liver homogenate tissues, Horsetail significantly increased GST, SOD, and GPX however, decreased MDA matched to TZ group. **Conclusion:** It could be concluded that horsetail (powder and extract) showed a promising protective role against adversely tartrazine affect and alteration biochemical markers in vital organs (liver and kidney) associated with decrease the oxidative stress. The mechanism may involve antioxidant effect and mitigation of lipid peroxidation. 11

Key words: Tartrazine, Horsetail *(Equisetum arvense)*, Hemoglobin, Antioxidants, Oxidative Stress, renal and hepatic functions.

INTRODUCTION

Color is one of the main characteristics of food. When the natural color of food is lost during processing, synthetic colors can be added to enhance the attractiveness and zest of food. Currently, the health risks associated with exposure to food additives are receiving considerable attention from consumers, nutritionists, and toxicologists **(Abd-Elhakim *et al.*, 2018A; B and C** and **Abo-El-Sooud *et al.*, 2018 A and B).** Tartrazine (TZ) as a well-known sulfonated azo dye, is an orange-colored water-soluble powder extensively used to color food products, known as synthetic lemon yellow **(Elhakim *et al.*, 2007** and **Sahnoun *et al.*, 2018)**. It is widely used as food additive which has been also applied in the drugs and cosmetics industries. It has been added to give a pleasant color to cake mixes, biscuits, jams, jellies, chewing gums, condiments, beverages, sauces, flavored chips and ice cream **(Mehedi *et al.*, 2009; Kashanian and Zeidali, 2011; Vidal *et al.*, 2018** and **Bonciu *et al.*, 2020).** Furthermore, in many developing countries it has been used as a substitute for saffron for cooking **(Mehedi *et al.*, 2009)**.

Tartrazine has been linked to the development of several disorders including asthma **(Ardern and Ram, 2001),** hyperactivity behavioral changes **(Bloom *et al.*, 2016** and **Oyewole and Oladele, 2016),** hypersensitivity reactions **(Leo *et al.*, 2018)**, neurotoxic **(Mohamed *et al.*, 2015** and **Yadav *et al.*, 2019)**, brain damage **(Hosieny *et al.*, (2021),** learning and memory defects **(Gao *et al.*, 2011),** gastrointestinal and liver injury **(El Rabey *et al.*, 2019 and Gijbels *et al.*, 2021)**, hormonal **(Abdel-Aziz *et al.*, 2019)**, endocrinal **(El-Sakhawy *et al.*, 2019)**, and teratogenic **(Hashem *et al.*, 2019)** potentials.

The acceptable daily intake (ADI) for T is 7.5 mg/kg b.w. **(Tanaka *et al.*, 2008 and Mpountoukas *et al.*, 2010).** At ADI level, its consumption is safe as no dangerous effects have been recorded in either humans or experimental models **(Tanaka *et al.*, 2008 and Poul *et al.*, 2009)**. Toxicokinetic studies showed that only 2% of the ingested tartrazine is directly absorbed and most tartrazine is broken down into smaller metabolites like sulfanilic

acid and aminopyrazolone in the colon **(Elhkim *et al.*, 2007).** Where the azo compounds, with the (-N=N-) functional group and aromatic rings linked to them, are reductively cleaved into aromatic amines. Some of these amines are toxic, carcinogenic and mutagenic **(Bloom *et al.*, 2016; Chung, 2000; Zhang and Ma, 2013** and **Rovina *et al.*, 2017)**. Moreover, these metabolites of tartrazine can generate reactive oxygen species (ROS), generating oxidative stress, decrease antioxidant defense mechanisms **(Boussada *et al.*, 2017)** and affect hepatic and renal architectures and biochemical profiles **(Himri *et al.*, 2011)**. **Gautam *et al.* (2010)** found that TZ administered to mice lead to hepato-cellular damage, and biochemical and reproductive alterations in high doses, and even in low doses. TZ has been reported to alter the hepatic and renal parameters and induce oxidative stress by forming free radicals **(Amin *et al.*, 2010 and Ali *et al.*, 2016)**. **Mpountoukas *et al.* (2010)** and **Imane *et al.* (2012)** indicated that TZ could potentially be genotoxic for human lymphocytes and could bind directly to DNA. Also, **Abd-Elhakim *et al.*, (2018A)** indicated that tartrazine exerts haematotoxic and immunotoxic effects following long-term exposure and induced significant anaemia and leukocytosis.

Horsetail (*Equisetum arvense*) belongs to the Equisetopsida family, it grows in several regions of in the temperate zones of the Northern Hemisphere **(Asgarpanah and Roohi, 2012** and **Hager, 2013).** It has long been used in traditional medicine **(Czygan and Wichtl, 1997; Madaus, 1990; Nagai *et al.*, 2005** and **World Health Organization, 2010)**. *E. arvense* is known as a "liver herb" in the American and European marketplaces and is gaining popularity as a supplement for improving liver function, hyperlipidemia, and alcohol metabolism **(Dos Santos *et al.*, 2005** and **Kong, 2013)**. The putative medicinal properties are supported by a number of studies, which found hepatoprotective (**Oh *et al.*, 2004),** renoprotective **(Boeing *et al.*, 2021** and **Pechter *et al.*, 2018)**, diuretic (**Wright *et al.*, 2007),** anti-bacterial (**Bessa Pereira *et al.*, 2012; Milovanović *et al.*, 2007 and Pallag *et al.*, 2018)**, anti-diabetes **(Fajri *et al.*, 2020 and Revilla *et al.*, (2002)**,

anticancer **(Batir-Marin *et al.*, 2021 B** and **Bhat *et al.*, 2020),** antioxidant effects **(Batir-Marin *et al.*, 2021 A and B; Cetojević-Simin *et al.*, 2010** and **Wu *et al.*, 2010)**, modulates oxidative stress (**Pallag *et al.*, 2018)** and antiproliferative properties **(Yamamoto *et al.*, 2004)**. Furthermore, anti-inflammatory properties for the treatment of wounds or inflammatory diseases such as arthritis have been described **(Asgharikhatooni *et al.*, 2015; Briceño-Cardona *et al.*, 2021; Costa-Rodrigues *et al.*, 2012؛ Do Monte *et al.*, 2004** and **Shiba *et al.*, 2021)**.

Field horsetail owes its healing effect to its chemical structure. Apart from the over 10% of inorganic substances (most of them are silicic acid and potassium salts), it contains mainly **(Mimica-Dukic *et al.*, 2008)** phytosterols, alkaloids, tannins, triterpenoids **(Četojević-Simin *et al.*, 2010; D'Agostino *et al.*, 1984** and **Oniszczuk *et al.*, 2014)**, ascorbic acid **(Nagai *et al.*, 2005)**, phenolic acids **(Francescato *et al.*, 2013)**, polyunsaturated acids, rare dicarboxylic acids and styrylpyrones **(Beckert *et al.*, 1997)**, and flavonoids **(Pittler, 2010** and **Saleh *et al.*, 1972)**. Studies of E. *arvense* have reported on its antioxidant **(Ismail *et al.*, 2020** and **Oh *et al.*, 2004)**. According to an in vitro experiment using $HepG_2$ cells, onitin and luteolin have liver-protective, superoxide-scavenging, and 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical-scavenging activities **(Oh *et al.*, 2004)**. Also, the relationship between the antioxidant activity and the content of phenolics in the horsetail extracts was identified **(Kim *et al.*, 2016; Masłowski *et al.*, 2020; Nunes *et al.*, 2017; Belščak-Cvitanović *et al.*, 2018** and **Patova *et al.*, 2019)**. Moreover horsetail is rich in many kinds of vitamins and trace elements. The high contents of these elements, high antioxidative activity this make horsetail is not only a health food, but also useful to protect against the various diseases **(Nagai *et al.*, 2005 and Oniszczuk *et al.*, 2014)**. The present work aims to evaluate the protective properties of horsetail against TZ toxicity, the effect on body-weight gain, hemoglobin, some biochemical parameters related to renal and hepatic functions and antioxidants / oxidative stress biomarkers in plasma and liver tissues.

MATERIALS AND METHODS

Materials:

- B-Tartrazine: was purchased from any local company for cosmetics, Cairo, Egypt.
- Horsetail was obtained from a local market in Cairo city, Egypt.
- Casein, vitamins, minerals and cellulose were obtained from El-Gomhariya Pharm. and Chem. Ind. Comp., Cairo, Egypt. While starch and corn oil were obtained from local market.
- Forty –two mature male albino rats of Sprague - Dawley strain weighing 110±5 g were obtained from Laboratory of Animal Colony, Helwan, Egypt.

Methods:

Horsetail powder was added to the diet as 10, 20% of the diet. The other part was used for preparation of methanol extract. Horsetail powdered was soaked in 500 ml of 80% ethanol with frequent agitation. Clarification was then carried out using vacuum filtration through filter paper watman 2. The resultant extract was concentrated to dryness in a rotary evaporator under reduced pressure at a temperature of 40°C. The rat dose of Horsetail extract was 10, 20 mg/kg b.wt according to **Irkin and Korukluoglu (2017)**.

Design experimental animals:

All animals were kept under observation for five days before experiment, fed on standard diet according to **NRC (1995)** and water ad libitum. The standard diet comprised of casein (200g/kg), corn starch (497g/kg), sucrose (100g/kg), cellulose (30 g/kg), corn oil (50g/kg), mineral mixture (100g/kg), vitamins mixture (20g/kg) and DL-methionine (3g/kg).

Rats were randomly classified into six groups (7 rats each). The first group kept as normal control fed standard diet only. The other five groups gave oral tartrazine-intoxicated, 300 mg /kg of body weight/day according to **El Golli *et al*. (2016)**. One group served as non-treated positive control while other groups treated with Horsetail powder and Extract as follow:

Group 1: normal control fed on the basal diet only.

Group2: positive control gave oral tartrazine-intoxicated, 300 mg /kg of body weight / day.
Group 3: positive control + 10%Horsetail powder / kg/ diet/day.
Group 4: positive control +10 mg Horsetail extract /kg b.wt.
Group 5: positive control +20%Horsetail powder / kg/ diet/day.
Group 6: positive control +20 mg Horsetail extract /kg b.wt.

The study was assigned for eight weeks. The food intake was calculated daily and the body weight gain was recorded weekly. Food and protein efficiency ratio (FER&PER) were calculated according to **Chapman *et al.* (1950)**.

Biochemical analysis:

At the end of the experiment, the rats were sacrificed to obtain blood samples. Heparenized blood was analyzed for estimation of hemoglobin (HB) and packed cell volume (PCV) according to **Drabkin (1949)** and **Mc Inory, (1954),** respectively.

Determination of liver and kidney functions: Serum alanine and aspartate aminotransferase (ALT, AST), alkaline phosphates (AP) enzymes, creatinine and uric acid were estimated according to **Reitman and Frankel (1957), Kind and King (1954), Hare (1950) and Fossati, *et al.*, (1980),** respectively.

Determination of antioxidant enzymes: Plasma glutathione transferase (GST), catalase, and superoxide dismutase enzymes (SOD) and nitric oxide (NO) were estimated according to **Habig (1974), Claiborne (1985), Beuchamp and Fridovich, (1971) and Green *et al.*, (1981)**, respectively.

liver of each rats were rapidly removed and perfuse with 50 to 100 of ice cold 0.9%NaCL solution for estimation of superoxide dismutase (SOD), glutathione peroxidase (GPX), glutathione S-transferase (GST) and malondialdehyde (MDA) according to **Beuchamp and Fridovich (1971), Weiss *et al* . (1980), Ellman (1958)** and **Uchiyama and Mihara (1978),** respectively.

Statistical analysis:

The obtained data were statistically analyzed using computerized SPSS. Effects of different treatments were analyzed by one way ANOVA (Analysis of variance) test using Duncan's

multiple range test and $p<0.05$ was used to indicate significance between different groups **(Snedecor and Cochran, 1967).**

RESULTS AND DISCUSSION

Effect of tartrazine and horsetail (powder and extract) on final body weight (FBW), body weight gain (BWG), feed intake, feed efficiency ratio (FER), protein efficiency ratio (PER) of the experimental rats groups:

The initial body weights of rats were similar in all groups and all of them gave positive body weight gain at the end of the experiment. Meanwhile, the administration of TZ to rats significantly decreased FBW, BWG%, FER and PER compared to the negative control group and all treatment groups as shown in **Table (1)**. It was noticed that the treated rats with TZ+ horsetail extract were the best mitigating ability against TZ toxicity; although, all of horsetail (powder and extract) showed a positive and protective effect on TZ toxicity. These results are in accordance with **Amin *et al.* (2010)** and **El Desoky *et al.* (2017)** who reported that tartrazine produced a significant decrease in body-weight gain. Also, **Arefin *et al.* (2017)** revealed a highly noticeable decrease in the body weight gain of mice at 400mg/kg dose compared with the negative control group. The significantly losses in body mass of rats fed TZ might be due to TZ reducing the palatability of food or otherwise resulting in avoidance. Furthermore, TZ might result in generation of free radicals, which resulted in oxidative stress that caused metabolic disorders and general losses of body mass **(El Desoky *et al.*, 2017)**. Body weight loss is considered by some authors to be a good reliable sensitive toxicity indicator **(Ezeuko *et al.*, 2007** and **Arefin *et al.*, 2017)**. The result indicates the potentiality of tartrazine to alter the growth as a function of toxicity. However, **Tanaka (2006)** indicated that there were no significant effects of tartrazine on the average feed intake. **Gautam *et al.* (2010)** observed a significant increase in the body weight of TZ experimental groups when compared to control group. *E. arvense* extract oral ingestion significantly increased the FBW and BWG% at doses of 25, 50,

75 mg/kg matched to CCl_4 intoxicated rats **(Ragheb and Alamri, 2020)**.

Table (1): Mean values ± SD of final body weight (FBW), body weight gain (BWG), feed intake, feed efficiency ratio (FER) and protein efficiency ratio (PER) of the experimental rat groups.

Groups / Variables	Normal control G1	Positive control G2	10% Horsetail powder G3	10mg Horsetail extract G4	20% Horsetail powder G5	20mg Horsetail extract G6
Initial weight (g)	115.55± 3.17[a]	110.41±2 .50 [a]	113.14 ± 3.45 [a]	112.33± 2.99 [a]	110.22 ±3.11 [a]	110.34 ± 3.14 [a]
Final Weight (g)	200.47±10. 11 [a]	165.71±1 5.6[b**]	189.71±10 .9 [a]	200.3±13. 80 [a]	205.5±12. 00 [a]	203.44±1 5.8 [a]
Weight Gain (g)	88.92±11.3 3 [a]	53.30±7. 71 [b**]	79.57±8.1 7 [a]	85.08±10. 22 [a]	90.92±11. 11 [a]	93.77±11 .21 [a]
Food Intake (g/d))	16.65± 2.11 [a]	13.20± 2.17 [a]	15.90± 2.11 [a]	16.35± 2.91 [a]	16.55± 2.18 [a]	16.75± 2.81 [a]
FER	0.093± 0.001 [a]	0.051±0. 002 b**	0.084± 0.003 [a]	0.092± 0.001 [a]	0.091± 0.001 [a]	0.094± 0.003 [a]
PER	0.46± 0.03 [a]	0.25± 0.01 [b**]	0.42± 0.03 [a]	0.46± 0.02 [a]	0.45± 0.04 [a]	0.47±0.0 3 [a]

Significant with control (-ve) group * P<0.05 ** P<0.01 *** P<0.001

Mean values in each raw having different superscript (a, b, c) denote significant difference.

The effect of tartrazine and horsetail (powder and extract) on blood hemoglobin (HB) and packed cell volume (PCV) of the experimental rats groups.

Results in Table (2) showed that administration of TZ decreased the value of hemoglobin (HB) and packed cell volume (PCV) in compared to control negative group. The HB and PCV values of positive control group was 6.19 gm/dl and 29.41%, meanwhile it was 14.08 gm/dl and 49.09%, respectively for negative control group. The treatment with horsetail (powder and extract) reversed the effect of TZ, as there was a significant increase in levels of HB and PCV in comparing to control positive group. It could be noticed that there were no significant changes between horsetail (powder and extract) groups and negative control group. The results of HB and PCV support the reports of

Daffallah *et al.* (2015); Aboel-Zahah *et al.* (1997); Sharma *et al.* (2009) and **Abd-Elhakim *et al.* (2018 A)** who revealed that the mean red blood cells (RBC), HB, PCV, and platelet count values were significantly decreased following treatment with tartrazine compared to the control group values. **Elekima and Christian (2019)** stated that administration of high doses far above the ADI of tartrazine induced decrease HB however, chronic treatment at ADI doses showed no significant difference after 30, 60, and 90 days. It is likely that the absorption of TZ and its metabolites in the blood plasma will adversely affect HB function and can even lead to impairment of its activity, as TZ can bind strongly to HB and induce significant conformational changes its transportation and metabolism in the human body can pose potential biological toxicity risk **(Basu and Kumar, 2016).** The interaction between HB and TZ possibly due to hydrogen bonding, hydrophobic and hydrophilic interactions **(Mandal and Ganguly, 2009** and ***Lu et al.*, 2007).** However, **Zokian and Mohamad (2010)** found that *Equisetum arvense* L. crude extracts (water and ethanolic) of (10, 50 mg/ml), significantly, increased the amount of hemoglobin *in vivo*, whereas higher concentration of (100mg/ml) decrease it.

Table (2): Mean values ± SD of blood hemoglobin (HB) and packed cell volume (PCV) of the experimental rats groups.

Groups / Variables	Normal control G1	Positive control G2	10%Horsetail powder G3	10mgHorsetail extract G4	20%Horsetail powder G5	20mgHorsetail extract G6
HB (gm/dl)	14.08± 1.18 [a]	6.19± 0.39 [b**]	11.04± 1.4 [a]	10.15± 1.98 [a]	12.08± 2.01 [a]	11.44± 1.82 [a]
PCV %	40.09± 3.82 [a]	29.41± 3.55 [b*]	35.79± 3.47 [b*]	37.14± 4.01 [a b]	36.11± 4.11 [a]	38.81± 3.17 [a]

Sig nificant with control (-ve) group * P<0.05 ** P<0.01 *** P<0.001

Mean values in each raw having different superscript (a, b, c) denote significant difference.

Effect of tartrazine and horsetail (powder and extract) on some liver and kidney functions of the experimental rats groups:

Data in Table (3) showed that treatment with tartrazine resulted in a significant ($p < 0.05$) increase in the activity of plasma aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (AlP) compared to negative control group. Also, it showed a significant ($p < 0.05$) increase in plasma uric acid and creatinine levels in tartrazine-treated animals. Meanwhile, treatment with horsetail powder or extract nearly restored the levels of AST, ALT, AlP, uric acid and creatinine when compared to the TZ treated group (Table 3). It could be noticed that horsetail extract fulfilled this role with slight more competence than horsetail powder. These results are parallel to **Aboel-Zahab *et al.* (1997); Mekkawy *et al.* (1998)** and **Sharma *et al.* (2005)** who indicated that TZ administration showed significant increases in serum AST, ALT, and alkaline phosphates activities. **Mekkawy *et al.* (1998); Himri *et al.* (2011); El-Wahab and Moram (2015)** and **Saxena and Sharma (2015)** attributed these results to hepatocellular damage caused by the toxic effects of these synthetic dyes which indicated by vacuolation, swelling, necrosis and pyknosis of the liver cells, This liver damage would releases greater than normal levels of intracellular enzymes into the blood. In the same concern, **Amin *et al.* (2010)** revealed that low and high doses of TZ induced significant increases in serum ALT, AST and ALP activities, also increased urea and serum creatinine levels in comparison to control group. Furthermore, **Helal *et al.* (2000)** found that oral administration of synthetic or natural colorants induced a marked increase in the serum AST, ALT, urea and creatinine levels of all treated groups after 30 days of treatment. **Ashour and Abdelaziz (2009)** observed significant elevations in serum creatinine and urea levels of rats dosed with organic azo dye (fast green) orally for 35 days. **Tawfek *et al.*, (2015)** found a significant increase in serum creatinine and urea in rats following the consumption of different types of feed additives including tartrazine, sunset

yellow and sodium benzoate. **Mehedi *et al.* (2013)** mentioned that tartrazine application induced significant elevations in urea and creatinine levels that is associated with impaired renal function and the inability of the kidney to filter body fluids. **Khayyat *et al.* (2017)** reported that the consumption of azo dyes caused a marked increase in the levels of AST, ALT, urea, uric acid and creatinine in rats. **Arefin *et al.* (2017)** revealed that TZ significantly increased serum creatinine and bilirubin levels. However, the pretreatment effect of *E. arvense* extract (25, 50, and 75 mg/kg) was remarkably protected against both liver and renal injury caused by CCl4. Where *E. arvense* extract significantly decreased serum ALT, AST, and ALP, creatinine, uric acid, and urea, as well as improve the serum protein and albumin levels **(Ragheb and Alamri, 2020)**. **Katikova *et al.* (2002)** investigated the hepatoprotection activity of *E. Arvense* herbs extract in a model of acute hepatitis produced by tetrachloromethane. The results offered that the extract protected the membrane through antioxidant action. This was displayed through lowered liver enzymes, total bilirubin, and lipid peroxidation products.

Table (3): Effect of tartrazine and horsetail (powder and extract) on some liver and kidney functions of the experimental rats groups

Groups / Variables	Normal control G1	Positive control G2	10%Horsetail powder G3	10mgHorsetail extract G4	20%Horsetail powder G5	20mgHorsetail extract G6
AST (µ /ml)	55.17± 5.81^{b}	72.39± 9.61^{a**}	49.37± 6.01^{b}	51.14± 8.10^{b}	48.21± 6.15^{b}	40.21± 4.13^{b}
ALT (µ /ml)	12.35± 1.12^{b}	28.55± 3.35^{a**}	15.71± 1.81^{b}	16.28± 2.01^{b}	18.13± 3.51^{b}	14.11± 3.65^{b}
AlP (µ /ml)	31.17± 5.66^{b}	50.38± 5.81^{a**}	37.80± 4.11^{b}	38.73± 4.37^{b}	38.34± 5.01^{b}	36.11± 3.11^{b}
Creatinine (mg/dl)	0.77± 0.01^{b}	1.95± 0.11^{a**}	0.99± 0.02^{b}	0.88± 0.12^{b}	0.75± 0.13^{b}	0.70± 0.15^{b}
Uric acid (mg/dl)	1.83± 0.26^{c}	4.41± 1.01^{a***}	2.11± 0.81^{b*}	2.41± 0.77^{b*}	2.17± 0.67^{b*}	1.74± 0.74^{c}

Significant with control (-ve) group * P<0.05 ** P<0.01 *** P<0.001

Mean values± SD in each column having different superscript (a, b, c) denote significant difference.

AST: aspartate transferase ALT: alanine aminotransferase ALP: alkaline phosphatase

Oh *et al.* (2004) showed that the methanolic extract of *E. arvense* produced a marked protective action against tacrine-prompted cytotoxicity in the Hep G2 cell line. Values of serum AST, ALT, ALP, uric acid and creatinine decreased gradually with increasing the level of horsetail as compared to the positive control group treated with prednisone acetate **(Arafa, 2016).** Administration of *E. arvense* to streptozitocin-induced diabetic rats for month lowers the level of serum glucose, urinary creatinine and microalbuminuria **(Soleimani *et al.*, 2007)**.

Effect of tartrazine and horsetail (powder and extract) on plasma oxidative/antioxidant biomarkers

The activity of antioxidants enzymes catalase (CAT), superoxide dismutase (SOD) and glutathione-S-transferase (GST) and oxidative stress biomarker nitric oxide (NO) revealed significant changes among different groups as shown in Table (4). The TZ group showed an obvious significant decrease in the activity of CAT (105.55± 10.14 µ /l plasma), SOD (20.25 ± 3.47 µ /l plasma) and GST (77.85 ± 8.40 µ /l plasma) when compared with the control group (385.21 ± 55.14, 70.13 ± 5.22 and 288.31 ± 33.27 µ /l plasma, respectively), while treatment with horsetail powder or extract nearly restored the levels of CAT, SOD and GST when compared to the TZ treated group (Table 4). A significant increase in the concentration of plasma NO level was seen in the TZ group (13.99 ± 1.44 µmol /l plasma) compared to the control group (2.17 ± 0.33 µmol /l plasma), as well as other treated groups. On the other hand, this increase was mitigated in the horsetail groups, the 10% and 20% horsetail powder groups (4.33 ± 1.11 and 3.11 ± 1.05 µmol /l plasma, respectively) and the 10mg and 20mg horsetail extract groups (3.22 ± 1.03 and 2.01 ± 1.21 µmol /l plasma, respectively), showing that horsetail extract fulfilled this role with slightly more competence than horsetail powder.

Oxidative stress is referred to a reactive oxygen species (ROS)/antioxidant imbalance. It occurs when the overall level of ROS exceeds the potential of the antioxidants. Thus, oxidative stress may occur because of accelerated ROS production, a drop of the antioxidant mechanisms, or both **(France's *et al.*, 2013)**. In the present study, elevated levels of NO clearly indicates oxidative stress occurrence in the tartrazine-treated rats. Where tartrazine metabolized inside the body into aromatic amines by intestinal microflora. These formed amines can generate ROS as part of their metabolism by the interaction of the active amino groups with nitrite or nitrate containing foods **(Moutinho *et al.*, 2007)**. NO is considered as important source of free radicals that might contribute to alterations in energy metabolism. **Peresleni *et al.* (1996)** demonstrated that oxidative stress to epithelial cells increases NO syntheses which results in elevated NO release, nitrite production and decreased cell viability. Also, the present results are in accordance with **Khayyat *et al.* (2017)** who reported that TZ consumption caused a marked increase in the levels of MDA and NO and a decreased level of total antioxidants in the serum of rats dosed with tartrazine compared to control group. **Tufarelli *et al.* (2021)** found that the concentrations of serum total superoxide dismutase (TSOD) and total antioxidant capacity (TAC) increased however, MDA decreased by adding horsetail to hen diet compared to control diet.

Table (4): Effect of tartrazine and horsetail (powder and extract) on plasma oxidative/antioxidant biomarkers

Groups / Variables	Normal control G1	Positive control G2	10% Horsetail powder G3	10mg Horsetail extract G4	20%Horsetail powder G5	20mgHorsetail extract G6
GST (µ /l)	288.31± 33.27 [a]	77.85± 8.40 [c***]	188.35± 22.17 [b*]	211.31± 23.81 [b*]	240.21± 23.71 [a]	278.15± 31.71 [a]
SOD (µ /l)	70.13± 5.22 [a]	20.25± 3.47 [b***]	63.14± 7.16 [a]	68.33± 6.35 [a]	71.31± 9.23 [a]	73.14± 7.81 [a]
Catalase (CAT) (µ /l)	385.21± 55.14 [a]	105.55± 10.14 [c***]	230.77± 32.11 [ab]	291.61± 31.61 [a]	277.11± 30.91 [a]	384.11± 39.11 [a]
NO (µmol /l)	2.17± 0.33 [b]	13.99± 1.44 [a***]	4.33± 1.11 [b]	3.22± 1.03 [b]	3.11± 1.05 [b]	2.01± 1.21 [b]

Significant with control (-ve) group * P<0.05 ** P<0.01 *** P<0.001

Mean values± SD in each column having different superscript (a, b, c) denote significant difference.

GST: glutathione-S-transferase SOD: superoxide dismutase NO: enzymes and nitric oxide

Effect of tartrazine and horsetail (powder and extract) on oxidative/antioxidant biomarkers of liver homogenate tissue:

The activity of antioxidant of liver homogenate tissue SOD, glutathione peroxidase (GPX), GST, and oxidative stress biomarker malondialdehyde (MDA) revealed significant changes among different groups as shown in Table (5). The TZ group showed an obvious significant decrease in the activity of GPX (25.14 ± 3.19 µ /mg tissue), SOD (35.81 ± 3.81 µ /mg tissue) and GST (1.51 ± 0.19 µ /mg tissue) when compared with the control group (130.33 ± 17.13, 155.81 ± 21.17 and 5.6 ± 0.66 µ /mg tissue, respectively), while treatment with horsetail powder or extract nearly restored the levels of GPX, SOD and GST when compared to the TZ treated group (Table 5). Significant increase in the concentration of MDA in liver tissue homogenate was seen in the TZ group (19.34 ± 3.14 mmol/g tissue) compared to the control group (9.45 ± 1.98 mmol/g tissue), as well as other treated groups. On the other hand, this increase was mitigated in the horsetail groups, the 10% and 20% horsetail powder groups (10.14 ± 2.61 and 10.33 ± 1.69 mmol/g tissue, respectively) and the 10mg and 20mg horsetail extract groups (9.11 ± 2.16 and 8.22 ± 1.91 mmol/g tissue, respectively), showing that horsetail extract fulfilled this role with slightly more competence than horsetail powder. These results are in agreement with **Omar, (2008)** who reported that oral administration of TZ for one month evoked a significant decrease in the activity of CAT and SOD and concentration of GSH as well as a significant increase in the concentration of MDA, a byproduct of lipid peroxidation, considered as an indicator of oxidative stress. Also, rats consumed low and high doses of TZ showed significant decreases in liver catalase, SOD and GSH activities, however it showed significant

increase in liver MDA in comparison to control group (**Amin *et al.*, 2010).** This may be attributed to the presence of the azo group that binds to aromatic rings in the molecular structure of TZ. Oral consumption of TZ induces reactive oxygen species (ROS) due to the formation of aromatic amines (nitro azo dye) through the action of azo reductase enzyme present in the intestinal microflora **(Bansal, 2005** and **Umbuzeiro *et al.*, 2005)**. As a result of ROS formation of the antioxidant defense mechanism of the cells including catalase, SOD, and GSH began to consumed to prevent the cell death by these toxic radicals so their levels in the tissue homogenate were decreased specially at higher doses when the need for them was increased, on the other hand MDA level was increased as a product of lipid peroxidation occurred by the ROS action on lipids of cellular membrane **(Bansal, 2005)**. Similarly, **Gao *et al.* (2011)** and **Mohamed *et al.* (2015)** found that the administration of TZ for 30 days resulted in a decline in the activities of CAT, glutathione peroxidase, and SOD while there was a rise in the level of MDA. TZ resulted in significantly increase of both MDA and total protein concentrations also, it resulted in statistically significant decrease of reduced glutathione (GSH), SOD, CAT and GPx concentrations **(El Desoky *et al.*, 2017). Eman *et al.* (2018)**, added that oral tartrazine at a daily dose of 50 mg/kg for 30 days showed significant decrease of GPx and significant increase of MDA levels in the cerebellar tissue.

Table (5): Effect of tartrazine and horsetail (powder and extract) on oxidative/antioxidant biomarkers of liver homogenate tissue

Groups / Variables	Normal control G1	Positive control G2	10%Horsetail powder G3	10mgHorsetail extract G4	20%Horsetail powder G5	20mgHorsetail extract G6
SOD (µ /mg)	155.81±21.17 [a]	35.81±3.81 [b***]	110.15± 11.15 [a]	131.25± 22.61 [a]	118.82± 17.34 [a]	143.32± 25.16 [a]
GPX (µ /mg)	130.33±17.13 [a]	25.14±3.19 [c***]	89.59± 7.95 [b*]	118.41± 11.18 [a]	114.38± 13.21 [a]	120.33± 21.35 [a]
GST (µ /mg)	5.6±0.66 [a]	1.51±0.19 [c***]	2.99± 0.88 [b*]	3.22± 0.97 [a]	3.29± 0.77 [a]	4.11± 0.98 [a]
MDA (nmol/g)	9.45±1.98 [b]	19.34±3.14 [a***]	10.14± 2.61 [b]	9.11± 2.16 [b]	10.33± 1.69 [b]	8.22± 1.91 [b]

Significant with control (-ve) group * P<0.05 ** P<0.01 *** P<0.001

Mean values in each column having different superscript (a, b, c) denote significant difference.

Albasher *et al.* (2020) revealed that oral tartrazine within the ADI (2.5 and 5 mg/kg daily) provoked significant increase of MDA in different brain regions. Also, **Hosieny *et al.* (2021)** showed that in tartrazine-treated group there was highly significant reduction in the mean value of GPx activity and highly significant elevation in the mean value of MDA level when compared with control groups. On the other hand, **Ragheb and Alamri (2020)** found that *E. arvense* extract decline serum level of MDA induced by CCl_4 injection. This effect was further explained by *E. arvense* phytochemical antioxidant constituents, which possesses a potent radical scavenging ability **(Khan *et al.*, 2013; Park and Jeon, 2008 and Rehman *et al.*, 2018).**

Conclusion:

The results of this study elucidated the promising protective role of horsetail (powder and extract) on hematological and biochemical profiles in hepatic and renal function, the antioxidant and oxidative stress biomarkers in the plasma and liver homogenate tissues parameters against TZ-toxicity in rats. The mechanism behind *E. arvense* action could be explained by its antioxidant and free radicals scavenging efficacy. Meanwhile, the consumption of foods containing food colorant tartrazine should be restricted as far as possible. However, further investigations should be carried out on different products to achieve full protection.

REFERANCES

- **Abdel-Aziz, H. M.; Alazouny, Z. M.; Abdelfadeel, K. F. and Abohashem, A. A. (2019).** Effect of tartrazine on thyroid gland of male rat and ameliorating role of curcumin (histological and immunohistochemical study). *Journal of Biochemistry and Cell Biology, 2(1): 2-11.*
- **Abd-Elhakim, Y.M.; Hashem, M.M.; El-Metwally, A. E.; Anwar, A.; Abo-EL-Sooud, K.; Moustafa G. G. and, Ali, H.A. (2018 A).** Comparative haemato-immunotoxic impacts of long-term exposure to tartrazine and chlorophyll in rats. *International Immunopharmacology, 63:145–154.*
- **Abd-Elhakim, Y.M.; Anwar, A.; Hashem, M.M.; Moustafa, G.G. ans Abo-El-Sooud, K. (2018 C).** Sodium acetate, sodium acid pyrophosphate, and citric acid impacts on isolated peripheral lymphocyte viability, proliferation, and DNA damage. *J. Biochem. Mol. Toxicol., 32(8):e22171. doi: 10.1002/jbt.22171. Epub 2018 Jul 18.*
- **Abd-Elhakim, Y.M.; Hashem, M.M.; Anwar, A.; El-Metwally, A.E.; Abo-El-Sooud, K.; Moustafa, G.G.; Mouneir, S.M. and Ali, H.A. (2018 B).** Effects of the food additives sodium acid pyrophosphate, sodium acetate, and citric acid on hemato-immunological pathological biomarkers in rats: relation to PPAR-α, PPAR-γ and tnfα signaling pathway. *Environ. Toxicol. Pharmacol., 62 98–106.*
- **Abo-El-Sooud, K.; Hashem, M.M.; Badr, Y.A.; Eleiwa, M.M.; Gab-Allaha, A.Q.; Abd-Elhakim, Y.M. and Bahy-El-Dien, A. (2018A)**. Assessment of hepato-renal damage and genotoxicity induced by long-term exposure to five permitted food additives in rats. *Environ Sci Pollut Res Int. 25(26):26341-26350.*
- **Abo-El-Sooud, K.; Hashem, M.M.; ElHakim, Y.M.A.; Kamel, G.M.; Gab-Allaha, A.Q. (2018B).** Effect of butylated hydroxyl toluene on the immune response of Rift Valley fever vaccine in a murine model. *Int. Immunopharmacol. 62 165–169.*

- **Aboel-Zahab, H.; El-Khyat, Z.; Sidhom, G.; Awadallah, R.; Abdel-al, W. and Mahdy, K. (1997).** Physiological effects of some food colouring additives on rats. *Bolletino Chimoco Farmaceutico., 136(10):615– 627.*
- **Albasher, G.; Maashi, N.; Alfarraj, S.; Almeer, R.; Albrahim, T.; Alotibi, F. and Mahmoud, A. M. (2020).** Perinatal exposure to tartrazine triggers oxidative stress and neurobehavioral alterations in mice offspring. *Antioxidants, 9(1): 53-67.*
- **Ali, F. A.; Abdelgayed, S. S.; El-Tawil, O. S. and Bakeer, A. M. (2016).** Toxicological and histopathological studies on the effect of tartrazine in male albino rats. *International Journal of Biological, Biomolecular, Agricultural, Food & Biotechnological Engineering, 10(8): 513-518.*
- **Amin, K.A.; Abdel Hameid, H. and Abd Elsttar, A. H. (2010).** Effect of food azo dyes tartrazine and carmoisine on biochemical parameters related to renal, hepatic function and oxidative stress biomarkers in young male rats. *Food Chem. Toxicol., 48: 2994-2999.*
- **Arafa, R. M. (2016).** *Equisetum arvense* (Horsetail): The Potential Effect of Natural Herb on Osteoporosis. *Egyptian J. of Nutrition, 3:109-139.*
- **Ardern, K.D. and Ram, F.S. (2001).** Tartrazine exclusion for allergic asthma. *Cochrane Libr 4 CD000460.*
- **Arefin, S.; Hossain, M. S.; Neshe, S. A. and Hussain, M. S. (2017).** Tartrazine induced changes in physiological and biochemical parameters in Swiss albino mice, Mus musculus. *Marmara Pharmaceutical Journal, 21(3):564-564.*
- **Asgarpanah, J. and Roohi, E. (2012).** Phytochemistry and pharmacological properties of *Equisetum arvense* L. *Journal of Medicinal Plants Research, 6: 3689-3693.*
- **Asgharikhatooni, A.; Bani, S.; Hasanpoor, S.; Alizade, S.M. and Javadzadeh, Y. (2015).** The Effect of Equisetum Arvense (Horse Tail) Ointment on Wound Healing and Pain Intensity after Episiotomy: A Randomized Placebo-Controlled Trial. *Iran Red Crescent Med J., 17(3): e25637.*

- **Ashour, A. A. and Abdelaziz, I. (2009).** Role of fast green on the blood of rats and the therapeutic action of vitamins C or E. *Int. J. Integr. Biol., 6 (1): 6-11.*
- **Bansal, A. K. (2005).** Modulation of N-nitrosodiethylamine induced oxidative stress by vitamin E in rat erythrocytes. *Human Exp. Toxicol., 24: 297-302.*
- **Basu, A. and Kumar, G.S. (2016).** Multispectroscopic and calorimetric studies on the binding of the food colorant tartrazine with human hemoglobin. *Journal of Hazardous Materials, 318:468–476.*
- **Batir-Marin, D.; Boev, M.; Cioanca, O.; Mircea, C.; Burlec, A.F.; Beppe, G.J.; Spac, A.; Corciova, A.; Hritcu, L.; Hancianu, M. (2021 A).** Neuroprotective and Antioxidant Enhancing Properties of Selective *Equisetum* Extracts. *Molecules, 26: 2565*. https://doi.org/10.3390/ molecules26092565
- **Batir-Marin, D.; Mircea, C.; Boev, M.; Burlec, A.F.; Corciova, A.; Fifere, A.; Iacobescu, A.; Cioanca, O.; Verestiuc, L.; Hancianu, M. (2021 B).** In Vitro Antioxidant, Antitumor and Photocatalytic Activities of Silver Nanoparticles Synthesized Using *Equisetum* Species: A Green Approach. *Molecules, 26: 7325. https://doi.org/10.3390/ molecules26237325*
- **Beckert, C.; Horn, C.; Schnitzler, J.-P.; Lehning, A.; Heller, W.; Veit, M. 1997).** Styrylpyrone biosynthesis in *Equisetum arvense*. *Phytochemistry, 44: 275–283.*
- **Belščak-Cvitanović, A.; Valinger, D.; Benković, M.; Tušek, A. J.; Jurina, T. and Komes, D. (2018).** Integrated approach for bioactive quality evaluation of medicinal plant extracts using HPLC-DAD, spectrophotometric, near infrared spectroscopy and chemometric techniques. *International Journal of Food Properties, 20: S2463–S2480.*

- **Bessa Pereira, C.; Gomes, P.S.; Costa-Rodrigues, J.; Almeida Palmas, R.; Vieira, L.; Ferraz, M.P.; Lopes, M.A.; and Fernandes, M.H. (2012).** *Equisetum arvense* hydromethanolic extracts in bone tissue regeneration: in vitro osteoblastic modulation and antibacterial activity. *Cell Prolif., 45:386–396.*
- **Beuchamp, C. and Fridovich, J. (1971).** Superoxide dismutase. Improved assay an assyapplicable to acryloamide gels. *Anal Biochem., 44: 276-287.*
- **Bhat, A. A.; Ahama, B.; Rehman, M.U. and Ahmad, P. (2020).** Impact of ethanolic extract of *Equisetum arvense* (EA1) on pancreatic carcinoma AsPC-1 cells. *Saudi J Biol Sci., 27(5):1260-1264.*
- **Bloom, S.; Chiang, K.; Demehri, S.; Kreshpanji, S.; McCaffrey, E.; Patel, K.; Sebastian, T.; Shan, S. and Sukri, L. (2016).** The Effect of Dietary Tartrazine on Brain Dopamine and the Behavioral Symptoms of Attention Deficit Hyperactivity Disorder. *Thesis submitted to the Faculty of the Graduate School of the University of Maryland, College Park, in partial fulfillment of the requirements of the Gemstone Program, University of Maryland*
- **Boeing, T.; Tafarelo Moreno, K.G.; Gasparotto, A., Jr.; Mota da Silva, L.; de Souza, P. (2021).** Phytochemistry and pharmacology of the genus *Equisetum* (Equisetaceae): A narrative review of the species with therapeutic potential for kidney diseases. Evidence-Based Complement. *Altern. Med., 2021: 1–17.*
- **Bonciu, E.; Rosculete, E. and Rosculete, C. (2020).** The clastogenic effect of tartrazine, a synthetic yellow dye, in plant meristematic tissues. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series, 49(1): 32-35.*
- **Boussada, M.; Lamine, J.; Bini, I.; Abidi, N.; Lasrem, M.; El-Fazaa, S. and El-Golli, N. (2017).** Assessment of a sub-chronic consumption of tartrazine (E102) on sperm and oxidative stress features in Wistar rat. *International Food Research Journal, 24(4): 1473-1481.*

- **Briceño-Cardona, K. L.; Romero, C. C.; Delgadillo, R.H.; Galindo-Rodríguez, S.A. and Solís-Soto, J.M. (2021).** *Equisetum* extracts are anti-inflammatory and antibacterial, an oral potential therapeutic agent. *International Journal of Applied Dental Sciences 2021; 7(1): 480-482.*
- **Cetojević-Simin, D.D.; Canadanović-Brunet, J.M.; Bogdanović, G. M.; Djilas, S. M.; Cetković, G. S.; Tumbas, V. T. and Stojiljković, B. T. (2010).** Antioxidative and antiproliferative activities of different horsetail (*Equisetum arvense* L.) extracts. *J Med Food, **13(2)**: 452–459.*
- **Chapman, D.G.; Gastilla, R. and Campbell, T.A. (1950).** Evaluation of protein in food. I. A. Method for the determination of protein efficiency ratio. Can. *J. Biochem. Physio., I (37) 679-686.*
- **Chung, K. (2000).** Mutagenicity and carcinogenicity of aromatic amines metabolically produced from azo dyes. *Environ Carcino Ecotoxicol Revs., 18: 51–74.*
- **Claiborne, A., (1985).** Catalase activities. *In: Greenwald, R.A. (Ed.), CRC Handbook of Methods in Oxygen Radical Research. CRC Press, Boca Raton, pp. 283–284.*
- **Costa-Rodrigues, J.; Carmo, S. C.; Silva, J. C. and Fernandes, M. H. R. (2012).** Inhibition of human in vitro osteoclastogenesis by *Equisetum arvense*. *Cell Prolif., **45**:566–576.*
- **Czygan, F.C. and Wichtl, M. (1997).** *Teedrogen und Phytopharmaka: Ein Handbuch für die Praxis auf wissenschaftlicher Grundlage.* Stuttgart: Wiss. Verl.-Ges.
- **D'Agostino, M.; Dini, A.; Pizza, C.; Senatore, F.; Aquino, R. (1984).** Sterols from *Equisetum arvense*. *Boll. Soc. Ital. Biol. Sper., 60: 2241–2245.*
- **Daffallah, A.A.; Abdellah, M. A.; Abdel-Rahim, A. E. and Ahmed, A. S. (2015).** Physiological effects of some artificial and natural food coloring on young male albino rats. *Journal of Food Technology, 2(2): 21-32.*

- **Do Monte, F. H. M.; dos Santos, J. G.; Jr, R.M.; Lanziotti, V. M. N. B.; Leal, L.K.A.M.; Cunha, G. M. (2004).** Antinociceptive and anti-inflammatory properties of the hydroalcoholic extract of stems from *Equisetum arvense* L. in mice. *Pharmacol Res Off J Ital Pharmacol Soc., **49**:239–243.*
- **Dos Santos, J. G.; Blanco, M. M.; Do Monte, F. H. M.; Russi, M.; Lanziotti, M. N. B.; Leal, L. K. A. M. and Cunha, G. M. (2005).** Sedative and anticonvulsant effects of hydroalcoholic extract of *Equisetum arvense*. *Fitoterapia, 76:508–513.*
- **Drabkin, D. (1949).** The standardization of hemoglobin measurements. *Am. J. Med. Sci., 21 (7): 710.*
- **El Golli, N.; Bini-Dhouib, I.; Jrad, A.; Boudali, I.; Nasri, B.; Belhadjhmida, N. and El Fazaa, S. (2016).** Toxicity induced after subchronic administration of the synthetic food dye tartrazine in adult rats, role of oxidative stress. *Recent Advances in Biology and Medicine, 2:20-28.*
- **El-Desoky, G.E.; Abdel-Ghaffar, A.; Al-Othman, Z.A.; Habila, M.A.; Al-Sheikh, Y.A.; Ghneim, H.K.; Giesy, J.P. and Aboul-Soud, M.A.M. (2017).** Curcumin protects against tartrazine-mediated oxidative stress and hepatotoxicity in male rats. *European Review for Medical and Pharmacological Sciences, 21: 635-645.*
- **Elekima, I. and Christian, S. G. (2019).** Toxicity Induced Haematological Alterations after Acute and Chronic Administration of Tartrazine (E102) in Albino Rats. *International Journal of Research and Reports in Hematology 2(3): 1-17.*
- **Elhkim, M.O.; Héraud, F.; Bemrah, N.; Gauchard, F.; Lorino, T.; Lambré, C.; Frémy, J.M. and Poul, J.-M. (2007).** New considerations regarding the risk assessment on tartrazine: an update toxicological assessment, intolerance reactions and maximum theoretical daily intake in France. *Regul. Toxicol. Pharmacol. 47 (3): 308–316.*

- **Ellman, G.L. (1958).** Liver glutathione. A colorimetric method for determining low concentration of glutathione. *Arch Biochem Biophys., 78: 443–450.*
- **El-Rabey, H. A.; Al-Seeni, M. N.; Al-Sieni, A. I.; Al-Hamed, A. M.; Zamzami, M. A. and Almutairi, F. M. (2019).** Honey attenuates the toxic effects of the low dose of tartrazine in male rats. *Journal of Food Biochemistry, 43(4): 1-11.*
- **El-Sakhawy, M. A.; Mohamed, D. W. and Ahmed, Y. H. (2019).** Histological and immunohistochemical evaluation of the effect of tartrazine on the cerebellum, submandibular glands, and kidneys of adult male albino rats. *Environmental Science and Pollution Research, 26(10): 9574–9584.*
- **El-Wahab, H. M. and Moram, G. S. (2015).** Toxic effects of some synthetic food colorants and/or flavor additives on male rats. *Toxicology International, 29(2):224-232.*
- **Eman, G. M.; Ibrahim, M. A. L.; Hassan, A. H. and Ebtehal, M. F. (2018).** Quercetin nanoparticles repressed liver and brain toxicities induced by tartrazine in rats. *Journal of Drug Delivery and Therapeutics, 8(5): 230-240.*
- **Ezeuko, V.C.; Nwokocha, C.R.; Mounmbegna, P.E. and Nriagu, C.C. (2007)**. Effect of Zingiber officinale on liver function of mercuric chloride induced hepatotoxicity in adult male Wistar rats. *Electron. J. Biomed., 3: 40-45.*
- **Fajri, M.; Ahmadi, A. and Sadrkhanlou, R. (2020).** Protective effects of Equisetum arvense methanolic extract on sperm characteristics and in vitro fertilization potential in experimental diabetic mice: An experimental study. *Int J Reprod Biomed., 18(2):93-104.*
- **Fossati, P.; Prencipe, L. and Berti, G. (1980).** Use of 3,5 dichloro-2-hydroxybenzene sulfonic acid /4-amlnophenazon chromogenic system in direct enzymatic assay of uric acid in serum and urine. *Clin. Chem., 26: 227-231.*

- **France's, D. E.; Ingaramo, P. I.; Ronco, M.T. and Carnovale, C. E. (2013).** Diabetes, an inflammatory process: oxidative stress and TNF-alpha involved in hepatic complication. *Journal of Biomedical Science and Engineering, 6: 645–653.*
- **Francescato, L.N.; Debenedetti, S.L.; Schwanz, T.G.; Bassani, V.L.; Henriques, A.T. (2013).** Identification of phenolic compounds in *Equisetum giganteum* by LC–ESI-MS/MS and a new approach to total flavonoid quantification. *Talanta, 105, 192–203.*
- **Gao, Y.; Li, C.; Shen, J.; Yin, H.; An, X. and Jin, H. (2011).** Effect of food azo dye tartrazine on learning and memory functions in mice and rats, and the possible mechanisms involved. *J Food Sci., 76(6):125–129.*
- **Gautam, D.; Sharma, G. and R. P. Goyal, R. P. (2010).** Evaluation of Toxic Impact of Tartrazine on Male Swiss Albino Mice. *Pharmacologyonline 1: 133-140.*
- **Gijbels, E.; Devisscher, L. and Vinken, M. (2021).** Testing in vitro tools for the prediction of cholestatic liver injury induced by non-pharmaceutical chemicals. *Food and Chemical Toxicology, 152: 112165.*
- **Green, L.C.; Wagner, D.A.; Glokowski, J.; Skipper, P.L.; Wishnok, J.S. and Tannenbaum, S.R. (1981).** Analysis of nitrite, nitrate, and [15N] nitrite in biological fluids. *Anal. Biochem1., 126: 131-138.*
- **Habig, W.H.; Pabst, M. J. and Takob, W.B. (1974).** Glutathione S-transferase. The first enzymatic step in meracapturic acid formation. *J, Biol. Chem., 249(22):7130-7139.*
- **Hager H. (2013).** *Hagers Handbuch der Pharmazeutischen Praxis.* Heidelberg: Springer. Hagers Handbuch der Pharmazeutischen Praxis: Drogen E-O.
- **Hare, R.S. (1950).** Endogenous creatinine in serum and urine. *Proc. Soc. Exp. Biol. Med., 74, 148.*

- **Hashem, M. M.; Abd-Elhakim, Y. M.; Abo-EL-Sooud, K. and Eleiwa, M. M. (2019).** Embryotoxic and teratogenic effects of tartrazine in rats. *Toxicological Research, 35(1): 75-81.*
- **Helal, G. E.; Zaahkouk,A.M and Mekkawy, A. H. (2000).** Effect of some food colorants (synthetic and natural products) of Young Albino rats. *Egypt. J. Hosp. Med., 1:103-113.*
- **Himri, I.; Bellahcen, S.; Souna, F.; Belmakki, F.; Aziz, M.; Bnouham, M.; Zoheir, J.; Berkia, Z.; Aziz, M. and Saalaoui, E. (2011).** A 90-day oral toxicity study of tartrazine, a synthetic food dye, in wistar rats. *International Journal of Pharmacy and Pharmaceutical Sciences, 3l (3): 159–169.*
- **Hosieny, N.M.; Ibrahim, M. E.; Ahmed, S.M. and Mohammad Z. M. Hassan, M. Z. M. (2021)**. Toxic Effects of Food Azo Dye Tartrazine on the Brain of Young Male Albino Rats: Role of Oxidative Stress. *Zagazig J. Forensic Med.& Toxicology, 19 (1): 60-73.*
- **Imane, H.; Faiza, S.; Mohammed, A.; Abdelkader, H. and Ennouamane, S. (2012).** DNA damage induced by tartrazine in rat whole blood using comet assay (single cell gel electrophoresis). *Adv Environ Biol., 6(11):2875–2881.*
- **Irkin, R. and Korukluoglu, M. (2017).** Control of *Aspergillus niger* with garlic, onion and leek extracts. *African Journal of Biotechnology, 6 (4), 384-387.*
- **Ismail, A.M.; Ouaid, T.; AL-Amery, M.; B. Maulood, B. and W. Serson, W. (2020).** A Preliminary Study of Phytochemicals in *Equisetum Arvenese* & *E. Ramosissmum* (Equisetaceae) Extracts from Northern Iraq. *FERN GAZ, 21(3):115-121.*
- **Kashanian, S and. Zeidali. S.H. (2011).** DNA Binding Studies of tartrazine food additive. *DNA Cell Biol., 30: 499-505.*
- **Katikova, O. I.; Kostin, I. and Tishkin, V. S. (2002).** Hepatoprotective effect of plant preparations. *Eksp Klin Farmakol., 65: 41–3.*

- **Khan, M.I.; Ahmad, M.; Khan, R.A.; Ullah, A.; Rehman, S. and Ullah, B. (2013).** Phytotoxic, antioxidant and antifungal activity of crude methanolic extract of *Equisetum debile*. *Int J Biosci., 3: 130–135.*
- **Khayyat, L.; Essawy, A.; Sorour, J. and Soffar, A. (2017).** Tartrazine induces structural and functional aberrations and genotoxic effects in vivo. *PeerJ., 5: e3041.*
- **Kim, Y.; Shin, K. and Choi, K. (2016).** In Vitro Antioxidant Properties of Equisetum arvense and Its Effects on Serum Lipid Levels in Mice Fed a High-Fat Diet. *Korean J. Food Nutr., 29(3): 347-356.*
- **Kind, P. R and King, E. J. (1954).** Estimation of alkaline phosphatase activity by determination of hydrolyzed phenol with aminoantipyrene. *J. Clin.Path., 7: 322.*
- **Kong, M. R. (2013).** Physiological activities of extracts from reproductive shoots and vegetative stems of horsetails, *Equisetum arvense* L. *Master's Thesis, Daegu Hanny Univ,*
- **Leo, L.; Loong, C.; Ho, X. L.; Raman, M. F. B.; Suan, M. Y. T. and Loke, W. M. (2018).** Occurrence of azo food dyes and their effects on cellular inflammatory responses. *Nutrition, 46(2): 36-40.*
- **Lu, X.; Zou, G. and Li, J. (2007).** Hemoglobin entrapped within a layered spongy Co_3O_4 based nanocomposite featuring direct electron transfer and peroxidase activity. *J. Mater. Chem. 17: 1427–1432.*
- **Madaus, G. (1990).** *Lehrbuch der Biologischen Heilmittel 10, Volume 10.* Mediamed: Ravensburg.
- **Mandal, P. and Ganguly, T. (2009).** Fluorescence spectroscopic characterization of the interaction of human adult hemoglobin and two isatins, 1-methylisatin and 1-phenylisatin: a comparative study. *J. Phys. Chem., B 113: 14904–14913.*

- **Masłowski, M.; Miedzianowska, J.; Czylkowska, A.; Efenberger-Szmechtyk, M.; Nowak. A. and Strzelec, K. (2020).** Anti-Oxidative Activity of Alcohol-Water Extracts from Field Horsetail (*Equisteum arvense*) in Elastomer Vulcanizates Subjected to Accelerated Aging Processes. *Materials, 13: 4903. Materials 2020, 13, 4903; doi:10.3390/ma13214903*
- **Mc Inory, l. (1954):** Amicro heamatocrit for determining the packed cell and hemoglobin concentration on capillary blood. *J. Clin., Path., (7): 32.*
- **Mehedi, N.; Ainad-Tabet, S.; Mokrane, N.; Addou, S.; Zaoui, C.; Kheroua, O. and Saidi, D. (2009).** Reproductive toxicology of tartrazine (FD and C Yellow No 5) in Swiss albino mice. *Am J Pharm Toxicol., 4(4):128–133.*
- **Mehedi, N.; Mokrane N, Alami O, Tabet S, Zaoui C, Kheroua O, Saidi D. (2013).** A thirteen-week ad libitum administration toxicity study of tartrazine in Swiss mice. *African Journal of Biotechnology, 12(28): 4519–4529.*
- **Mekkawy, H. A.; Ali, M. O.and El-Zawahry, A.M. (1998).** Toxic effect of synthetic and natural food dyes on renal and hepatic functions in rats. *Toxicol. Lett., 95 (1):155.*
- **Milovanović, V.; Radulović, N.; Todorović, Z.; Stanković M, Stojanović G. (2007).** Antioxidant, antimicrobial and genotoxicity screening of hydro-alcoholic extracts of five serbian Equisetum species. *Plant Foods Hum Nutr Dordr Neth., 62:113–119.*
- **Mimica-Dukic, N.; Simin, N.; Cvejic, J.; Jovin, E.; Orcic, D.; Bozin, B. (2008).** Phenolic Compounds in Field Horsetail (*Equisetum arvense* L.) as Natural Antioxidants. *Molecules, 13: 1455–1464.*
- **Mohamed, A. A. R.; Galal, A. A. A. and Elewa, Y.H.A. (2015).** Comparative protective effects of royal jelly and cod liver oil against neurotoxic impact of tartrazine on male rat pup's brain. *Acta Histochem., 117 (7): 649–658.*

- **Moutinho, I. L.D.; Bertges, L. C. and Assis, R. V. C. (2007)**. Prolonged use of the food dye tartrazine (FD & C Yellown degrees 5) and its effects on the gastric mucosa of Wistar rats. *Brazilian Journal of Biology., 67(1): 141–145.*
- **Mpountoukas, P.; Pantazaki, A.; Kostareli, E.; Christodoulou, P.; Kareli, D.; Poliliou, S.; Mourelatos, C,; Lambropoulou, V. and Lialiaris, T. (2010).** Cytogenetic evaluation and DNA interaction studies of the food colorants amaranth, erythrosine and tartrazine. *Food Chem Toxicol., 48:2934–2944.*
- **Nagai, T.; Myoda, T. and Nagashima, T. (2005).** Antioxidative activities of water extract and ethanol extract from field horsetail (tsukushi) *Equisetum arvense* L. *Food Chem. 91: 389–394.*
- **NRC (National Research Council) (1995).** Nutrient requirement. Fourth reviser edition. *Pp: 29-30 National Academy Press Washington, Animals, D.C. Environ. Sci. Health, 25: 487-494.*
- **Nunes, R.; Pasko, P.; Tyszka-Czochara, M.; Szewczyk, A.; Szlosarczyk, M. and Carvalho, I. S. (2017).** Antibacterial, antioxidant and anti-proliferative properties and zinc content of five south Portugal herbs. *Pharmaceutical Biology, 55: 114–123.*
- **Oh, H; Kim, D.H.; Cho, J.H.; and Kim, Y.C. (2004).** Hepatoprotective and free radical scavenging activities of phenolic petrosins and flavonoids isolated from Equisetum arvense. *J Ethnopharmacol., 95:421–424.*
- **Omar, H. H. (2008).** Algal decolorization and degradation of monoazo and diazo dyes. *Pak J Biol Sci., 11(10):1310–6.*
- **Oniszczuka, A.; Podgórski, R.; Oniszczuk, T.; Zukiewicz-Sobczak, W.; Renata Nowak, R. and Monika Waksmundzka-Hajnos, M. (2014)**. Extraction methods for the determination of phenolic compounds from *Equisetum arvense L.* herb. *Industrial Crops and Products, 61: 377–381.*

- **Oyewole, O. I. and Oladele, J. O. (2016)**. Assessment of cardiac and renal functions in Wistar albino rats administered carmoisine and tartrazine. *Advances in Biochemistry, 4(3):21-25.*
- **Pallag, A.; Filip, G. A.; Olteanu, D.; Clichici, S.; Baldea, I.; Jurca, T.; Micle, O.; Vicaş, L.; Marian, E.; Soriţău, O.; Cenariu, 5 and Mureşan, M. (2018).** *Equisetum arvense* L. Extract Induces Antibacterial Activity and Modulates Oxidative Stress, Inflammation, and Apoptosis in Endothelial Vascular Cells Exposed to Hyperosmotic Stress. *Oxid Med Cell Longev., Volume 2018, Article ID 3060525, 14 pages.*
- **Park, E.Y. and Jeon H. (2008).** Antioxidant and anti-inflammatory activities of *Equisetum hyemale*. *Nat Prod Sci., 14: 239–43.*
- **Patova, O. A.; Smirnov, V.V.; Golovchenko, V. V.; Vityazev, F.V.; Shashkov, A.S. and Popov, S. V. (2019).** Structural, rheological and antioxidant properties of pectins from *Equisetum arvense* L. and *Equisetum sylvaticum* L. *Carbohydrate Polymers, 209 (2019) 239–249.*
- **Pechter, Ü.; Ingrid Kalev, I. and Ots-Rosenberg, M. (2018).** Renoprotective and blood pressure lowering impact of *Equisetum arvense* and Viscumalbum therapy in experimental model of chronic kidney disease. *World J Cardiovascular Dis., 8: 545–56.*
- **Peresleni, T.; Noiri, E.; Bahou, W. and Goligorsky, M. (1996).** Anti-sense oligodeoxynucleotides to inducible NO synthase rescue epithelial cells from oxidative stress injury. *American Journal of Physiology, 270(6): 971–977.*
- **Pittler, M. H. (2010).** Herbal Drugs and Phytopharmaceuticals. *Focus on Alternative and Complementary Therapies, 15(3): 210-213.*
- **Poul, M.; Jarry, G.; Elhkim, M.O. and Poul, J.-M. (2009).** Lack of genotoxic effect of food dyes amaranth, sunset yellow and tartrazine and their metabolites in the gut micronucleus assay in mice. *Food Chem. Toxicol., 47 (2): 443–448.*

- **Ragheb, E.M. and Alamri, Z.Z. (2020).** Efficacy of *Equisetum Arvense* Extract Against Carbon Tetrachloride Induced Liver and Kidney Injury in Rats. *International Journal of Pharmaceutical and Phytopharmacological Research (eIJPPR), 10(5):43-52.*
- **Rehman, T.; Shad, M.A.; Nawaz, H.; Andaleeb, H. and Aslam, M. (2018).** Biochemical, phytochemical and antioxidant composition of *Equisetum debileRoxb*. *Biochemist &Analytical Biochemist, 7(4):1–6.*
- **Reitman, S. and Frankel, S. (1957).** Enzymatic determination of liver function. *Am. J .Clin. path., 28:56-63.*
- **Revilla, M.C.; Andrade-Cetto, A.; Islas, S. and Wiedenfeld, H. (2002).** Hypoglycemic effect of *Equisetum myriochaetumaerial* parts on type 2 diabetic patients. *J Ethnopharmacol, 81: 117-120*
- **Rovina, K.; Siddiquee, S. and Shaarani, S. M. (2017).** A review of extraction and analytical methods for the determination of tartrazine (E 102) in foodstuffs. *Crit. Rev. Anal. Chem. 47: 309e324.*
- **Sahnoun, S.; Boutahala, M.; Chafia Tiar, C. and Kahou, A. (2018).** Adsorption of tartrazine from an aqueous solution by octadecyltrimethylammonium bromide-modified bentonite :Kinetics and isotherm modeling. *C. R. Chimie., 21: 391-398.*
- **Saleh, N.A.M.; Majak, W. and Towers, G. H. N. (1972).** Flavonoids of *Equisetum* species. Phytochemistry, 11: 1095–1099.
- **Saxena, B. and Sharma, S. (2015).** Food color induced hepatotoxicity in Swiss albino rats, Rattus norvegicus. *Toxicology International, 22(1):152–157.*
- **Sharma, G.; Gautam, D. and Goyal, P. R. (2009).** Tartrazine induced haematological and serological changes in female Swiss albino mice, Mus musculus. *Pharmacologyonline, 3:774–788.*

- **Sharma, S.; Goyal, R.P.; Chakravarty, G. and Sharma, A. (2005).** Haemotoxic effects of chocolate brown, a commonly used blend of permitted food color on Swiss Albino mice. *Asian J. Exp. Sci., 19 (2):93-103.*
- **Shiba, F.; Miyauchi, M.; Chea, C.; Furusho, H.; wasaki. S.I.; Shimizu, R.; Ohta, K.; Nishihara, T. and Takata, T. (2021).** Anti-infammatory effect of glycyrrhizin with *Equisetum arvense* extract. *Odontology, 109:464–473*
- **Snedecor, G.W. and Cochran, W.G. (1967).** Statistical Methods. *7th Ed., The Lowa State University Press. Ames, Lowa, U.S.A.*
- **Soleimani, S.; Azarbaizani, F.F. and Nejati, V. (2007).** Effect of *Equisetum arvense* L. (Equisetaceae) in microalbuminuria and creatinine excretion in streptozotocin-induced diabetes in male rats. *International Journal of Pharmacology. 3(2): 155-159.*
- **Tanaka, T. (2006).** Reproductive and neurobehavioural toxicity study of tartrazine administered to mice in the diet. *Food Chem Toxicol., 44:179–187.*
- **Tanaka, T.; Takahashi, O.; Oishi, S. and Ogata, A. (2008).** Effects of tartrazine on exploratory behavior in a three-generation toxicity study in mice. *Reprod. Toxicol., 26(2):156-163.*
- **Tawfek, N.; Amin, H.; Abdalla. and Fargali, S. (2015).** Adverse effects of some food additives in adult male albino rats. *Current Science International, 4(4):525–537.*
- **Tufarelli, V.; Baghban-Kanani, P.; Azimi-Youvalari, S.; Hosseintabar-Ghasemabad, B.; Slozhenkina, M.; Gorlov, I.; Seidavi, A.; Aya¸san, T. and Laudadio, V. (2021).** Effects of Horsetail (*Equisetum arvense*) and Spirulina (*Spirulina platensis*) Dietary Supplementation on Laying Hens Productivity and Oxidative Status. *Animals, 11: 335. https:// doi.org/10.3390/ani11020335.*
- **Uchiyama, M. and Mihara, M. (1978).** Determination of malondialdhyde precursor in tissues by thiobarbituric acid test. *Anal. Biochem., 86 (1);271-278.*

- **Umbuzeiro, G. A.; Freeman, H. S.; Warren, S. H.; Oliveira, D. B. P.; Terao, Y.; Watanabe, T. and Claxton, L. D. (2005).** The contribution of azo dyes to the mutagenic activity of the Cristais River. *Chemosphere, 60(1):55–64*
- **Vidal, M.; Garcia-Arrona, R.; Bordagaray, A.; Ostra, M. and Albizu, G. (2018).** Simultaneous determination of color additives tartrazine and allura red in food products by digital image analysis. *Talanta, 184: 58e64*
- **Weiss, C.; Marker, H. S. and Lehrer, G. M. (1980):** Sensitive fluorometric assays for glutathione peroxidase and reductase. *Anal Biochem., 106: 512–516.*
- **World Health Organization (2010).** WHO monographs on medicinal plants commonly used in the Newly Independent States (NIS). *Geneva: World Health Organization.*
- **Wright, C.I.; Van-Buren, L.; Kroner, C.I. and Koning, M.M.G. (2007).** Herbal medicines as diuretics: a review of the scientific evidence. *J Ethnopharmacol., 114:1–31.*
- **Wu L-C, Jou AF-J, Chen S-H, Tien C-Y, Cheng C-F, Fan N-C, Ho J-AA. (2010).** Antioxidant, anti-inflammatory and anti-browning activities of hot water extracts of oriental herbal teas. *Food Funct., **1**:200–208.*
- **Yadav, M.; Jindal, D. K.; Parle, M.; Kumar, A. and Dhingra, S. (2019).** Targeting oxidative stress, acetylcholinesterase, proinflammatory cytokine, dopamine and GABA by eucalyptus oil (*Eucalyptus globulus*) to alleviate ketamine-induced psychosis in rats. *Inflammopharmacology, 27(2):30 1-311.*
- **Yamamoto, Y.; Inoue, T. and Hamako, J. (2004).** Crude proteins extracted from *Equisetum arvense* L. increases the viability of cancer cells in vivo. *Seibutsu Shiryo Bunseki., 27(5):409–412.*
- **Zhang, G. and Ma Y. (2013).** Mechanistic and conformational studies on the interaction of food dye amaranth with human serum albumin by multispectroscopic methods. *Food Chem., 136:442–449.*
- **Zokian, S.A. and Mohamad, B. (2010).** Study on the effect of the water and ethanolic extract of *Equisetum arvense* L. on some hematological parameters in the Albino mice. *Journal of Biotechnology Research Center, 4(1): 17-22.*

التأثير الوقائي لنبات ذيل الحصان (*Equisetum arvense* L.) ضد سمية صبغة الأزو الغذائية التارترازين علي بعض المعاييرالبيوكيميائية ومضادات الأكسدة لدى ذكور الفئران: دور الإجهاد التأكسدي

رانيا شمس الدين فخر الدين
قسم الاقتصاد المنزل- كلية التربية النوعية
جامعة طنطا – مصر

سماح عبد الله السملاوى
قسم الاقتصاد المنزل- كلية التربية النوعية
جامعة طنطا – مصر

الملخص

هناك اهتمام متزايد في الوقت الحاضر باستخدام النباتات الطبية، هذا و يعتبر لنبات ذيل الحصان (*Equisetum arvense* L.) من العائلة Equisetaceae استخدامات عديدة في الطب التقليدي وله العديد من التأثيرات الدوائية التى يرتبط معظمها بتأثيراته المضادة للأكسدة. ومن جانب أخر تعتبرالتارترازين (TZ) مادة صناعية من صبغات الآزو العضوية التى تستخدم على نطاق واسع كمادة ملونة مضافة للأغذية والأدوية ولمستحضرات التجميل و من الممكن أن تؤدي إلى الإجهاد التأكسدي الذي يؤدى بالتالي اضطرابات أيضية مثل تسمم الكبد والكلى. ولهذا تم تصميم هذه الدراسة لتقييم الخصائص الوقائية لنبات ذيل الحصان ضد الإجهاد التأكسدي المحدث بوساطة TZ في الفئران حيث تم تقسيم اثنين وأربعين فأرًا بشكل عشوائي إلى ست مجموعات (٧ فئران لكل مجموعة). تم الاحتفاظ بالمجموعة الأولى(G1) بدون اى معالجة وسميت بالمجموعة الضابطة السالبة، بينما أعطت المجموعات الخمس الأخرى جرعة من التارترازين فمويا ٣٠٠ مجم/كجم من وزن الجسم/يوم. وتم الاحتفاظ بمجموعة واحدة كمجموعة ضابطة موجبة (G2) ، فى حين عولجت باقى مجموعات الـ TZ الأخرى بمسحوق ومستخلص ذيل الحصان على النحوالتالي:المجموعةالثالثة (G3) بمسحوق ذيل الحصان٪١٠/كجم وجبة/يوم، المجموعةالرابعة(G4): 10مجم مستخلص ذيل الحصان/كجم من وزن الفئران، المجموعةالخامسة (G5)20٪ مسحوق ذيل الحصان/كجم وجبة/يوم والمجموعةالسادسة (G6): ٢٠ مجم مستخلص ذيل الحصان/ كجم من وزن الفئران. ولقد أظهرت النتائج أن المعالجة بذيل الحصان سواءالمسحوق أوالمستخلص في جميع الجرعات أدى الى تحسن معنوى ، حيث أدى الى زيادة أوزان أجسام الفئران ، بالاضافة الى ارتفاعا معنوا لكلا من HB، PCV ، وظائف الكبد (ALT، AST و ALP) ووظائف الكلى (الكرياتينين وحمض البوليك) بالمقارنة بالمجموعة الضابطة الموجبة (TZ). وارتبط ذلك بارتفاع كبير للمؤشرات الحيوية لمضادات الأكسدة في البلازما GST و SOD و CAT وانخفاض العلامات الحيوية للاجهاد التأكسدي NO ، و كذلك للمؤشرات الحيوية لمضادات الأكسدة في أنسجة الكبد، حيث أدت المعالجة بذيل الحصان الى زيادة نسب كلا من GST و SOD و GPX معنويا وانخفض مستوى الـ MDA معنويا بالمقارنة بالمجموعة الضابطة الموجبة (TZ). الخلاصة: يمكن الاستنتاج بأن المعالجة بذيل الحصان سواء المسحوق أوالمستخلص أظهرت دورًا وقائيًا واضحا ضد التأثير السلبي للتارترازين وغيرت العلامات البيوكيميائية لأعضاء الحيوية مثل الكبد والكلى وارتبط ذلك بتقليل الإجهاد التأكسدي وذلك من خلال تأثيره المضاد للأكسدة.

الكلمات المفتاحية: التارترازين ، ذيل الحصان (*Equisetum arvense*) ، الهيموجلوبين ، مضادات الأكسدة ، الإجهاد التأكسدي ، وظائف الكلى والكبد.