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Hemato-biochemical study of tartrazine in wistar rats (*Rattus norvegicus*)

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Abstract
The present study on toxicopathology of tartrazine was carried out on 80 Wistar rats comprised of 40 male and 40 female divided into four equal groups, *viz*., Groups I, II, III and IV. Group I served as control and received distilled water, while Groups II, III and IV received tartrazine @ 50, 100, 200 mg/kg body weight orally dissolved in drinking water for 90 days, respectively. The experimental animals were closely observed daily for clinical and behavioural changes and weekly for body weight. All rats were subjected to haemato-biochemical alterations and organ weight studies on 91st day of experiment. The daily observation of animals for clinical and behavioural signs as well as weekly body weights revealed no significant change in treatment groups throughout the experimental period of 90 days as compared to control. The haematological parameters revealed significant (P<0.05) increase in the values of lymphocytes and decrease in neutrophils value of all treatment group of both sex. No any significant change was recorded in any other haematological parameters in any of the treatment groups. The biochemical parameters revealed significant (P<0.05) increase in ALT, AST, ALP and GGT value of all treatment groups of both sex, whereas, total protein values showed significant (P<0.05) increase only in female treatment groups.

Keywords: Tartrazine, toxicopathology, haemato-biochemical, wistar rats

Introduction
Food additives are substances mixed with primary food materials in order to enhance its flavor, taste, appearance, food value and conservation that will fulfill the demand of wholesome and tasty food for rapidly increasing population round the year [1]. Food additives are categorized into six main groups as preservatives, nutritive essences, flavouring, colouring, texturizing and miscellaneous compounds [2].

Food dyes are constituents when added to foods or food products, they change, uphold or improve the colour of the foods or food products by covalently binding to the food particles [3]. The human beings have been consuming colour additives for a very ancient time as early as 1500 BC in Egyptian cities for improving expression of food products and hiding the quality of products [4]. Colours are vital components of food and food products which gives the first imprint on the mind of the consumer [1]. In general, dyes are used in both commercial food production and homemade cooking. The application of dyes is moreover seen in textile, leather, paper, rubber, home craft projects, cosmetics and even in pharmaceutical industries also [5].

Tartrazine is extensively used food dye amongst all dyes that are used in the market for yellow colour purpose [6]. Tartrazine (TAZ) also known as E 102, FD and C, Yellow No. 5 is an azo dye and salt of chemical formula 3-carboxy-5-hydroxy-1-(4'-sulphophenyl)-4-(4'-sulphophenylazo) pyrazoletri-sodium salt [7]. It is the most repeatedly used food colorants to accomplish yellow colour in ice-cream, candy, soft drinks, sweets, juices, jams, jelly, soups, sauces, cake mixes, mustard and sodas. In addition, it has been extensively used to colouring agents in human pharmaceuticals such as vitamins, antacids, capsule and gel [8]. Saffron is replaceable by this food colorant which is used in cooking as a substitute [6]. Tartrazine is converted into aromatic amine sulfanilic acid after being metabolized by the gastrointestinal microflora [9] and the intended aromatic amines can produce Reactive Oxygen Species (ROS) by interface of these amino groups with nitrite or nitrate-containing foods or in the stomach. The ROS such as superoxide anion, hydroxyl radical, and H2O2 could be manufactured in the metabolism of nitrosamines and rise oxidative stress [10].

Several safety concerns were described for Tartrazine, but the evidence is limited. The consumption of Tartrazine exceeds their acceptable daily intake and higher exposure may cause health risk in human being. Due to paucity of information available on Tartrazine toxicity in India, the present study has been planned

Material and Methods

Location

The present study was carried out at the Department of Veterinary Pathology, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Sardarkrushinagar - 385 506, Gujarat, India.

Experimental animals

A total of 80 Wistar rats were procured from Pavo Research Solutions, Dashrath, Vadodara, Gujarat, India. Before grouping and dosing, the procured rats were retained under acclimatization for 15 days.

Institutional Animal Ethics Committee (IAEC) approval

The protocol was presented before the Institutional Animal Ethics Committee on 13th January 2021 and the protocol was approved as VETCOLL/IAEC/2021/17/PROTOCOL-07 by the IAEC of the College of Veterinary Science and Animal Husbandry, Kamdhenu University, Sardarkrushinagar-385 506, Gujarat, India.

Housing and environmental conditions

Animal management and treatment procedures complied with the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), New Delhi, India. All the rats were housed in polypropylene cages at the laboratory animal house facility of the college (Figs. 1 and 2) in an environmentally controlled room with 22 ± 3 ºC temperature and 30-70 per cent humidity. Light/dark cycles of 12/12 hours were provided throughout the acclimatization and study period. Corncob was used as a bedding material. Rats were identified by tail markings. All essential managemental procedures were adopted to keep the rats free from stress. Rats had *ad libitum* access to standard pellet diet (VRK Nutritional Solution, Sangli, Maharashtra, India) and RO drinking water throughout the study period.

Fig 1: Laboratory animal facility

Fig 2: Housing of rats in polypropylene cages at the Laboratory animal facility

Experimental design

The toxicopathology of Tartrazine was studied in 80 Wistar rats comprising of 40 male and 40 female rats. All 80 rats were randomly divided into 4 different groups. Each group consisted of 20 rats. The groups were numbered as groups I to IV. Group I served as control and received only distilled water, while groups II, III and IV were received test compound tartrazine at the dose of 50, 100 and 200 mg/kg/day respectively in distilled water for 90 days.

Numbering and identification

Identification of animals was done by tail marking with a permanent color marker. Cage labels and body marking were specific to spot the animals. Five animals were kept in one cage. One ring for number one, two rings for number two, three rings for number three, four rings for number four and no marking for number five.

Test compound

The test compound tartrazine was purchased from Sigma-Aldrich, Mumbai, India.

Clinical observations

Observations for morbidity and mortality were made twice daily throughout the study. During the acclimation period of 10 days, clinical observations were recorded once daily. Clinical observations were conducted at least twice each day during toxicity study. Water consumption was daily noted in each group of rats.

Body weight

The body weight of each rat was recorded one day before starting treatment and at weekly intervals throughout the study. The last bodyweight was noted one day before blood collection, exactly before keeping the animals for overnight fasting (Day 90).

Necropsy and organ weight

All the rats were euthanized, on the 91st day of the study. The rats have been fasted overnight before necropsy. Rats were anesthetized using isoflurane. The organs were collected from all the animals. The organs were cleaned by using filter paper and then weighed by using an analytical balance.

Clinical pathology

Blood was collected from the retro-orbital plexus (Fig. 3) with the help of a capillary tube for hematology and biochemical estimation on the 91st day of the experiment.

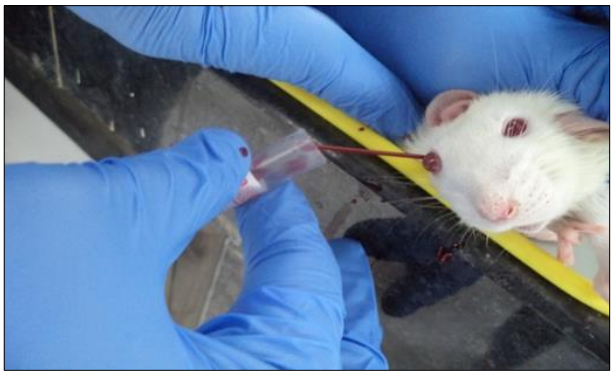

Fig 3: Blood collection from retro orbital plexus of rat

Haematological profile

The collection of blood was done in sterilized vials containing 4.0 per cent potassium ethylene diaminetetra acetic acid (K_3EDTA) for estimation of hematological parameters and in serum clot activator vial for biochemical estimation. Blood smears were prepared within 3 hours of collection and stained with Giemsa for evaluation of platelet, erythrocyte morphology and basophils count. Following hematological parameters were recorded by using Automated Blood Analyzer (ExigoHaematology Analyzer, Boule Medical AB, Sweden) through impedance method. Haemoglobin (Hb) (g/dL), Total Erythrocyte Count (TEC) (106/µL), Packed Cell Volume (PCV) or Haematocrit HCT (%), Mean Corpuscular Volume (MCV) (fL), Mean Corpuscular Haemoglobin Concentration (MCHC) (g/dL), Mean Corpuscular Haemoglobin (MCH) (pg), Total Leukocytes Count (TLC) (103/µL), Differential Leukocyte Count (DLC), Red cell Distribution Width (RDW) (%), Red cell Distribution Width (RDW) (a) and Mean Platelet Volume.

Biochemical profile

Following biochemical parameters were analysed by commercially available reagent kits through Fully Automated Biochemistry Analyzer (RANDOX-RX Monaco, United Kingdom). Alanine Aminotransferase (ALT) (U/L), Aspartate Aminotransferase (AST) (U/L), Alkaline Phosphatase (ALP) (U/L), Urea (mg/dL), Creatinine (mg/dL), Total Protein (TP) (g/dL), Albumin (g/dL), Cholesterol (mg/dL), Triglycerides (mg/dL), Glucose (mg/dL), Magnesium (mg/dL), Calcium (mg/dL), Phosphorous (mg/dL), Gamma-Glutamyltransferase (GGT) (U/L), Iron (mg/dl).

Statistical analysis

The statistical analysis of data generated on various parameters was subjected to statistical analysis using 2-way analysis of variance (ANOVA). Pair-wise comparisons with control, for each sex separately, was made using Dunnett's test [11].

Results and Discussion

Symptomatology

All the rats were observed for the development of clinical and behavioral symptoms throughout the experimental period of 90 days. Rats of all four groups did not show any noticeable symptoms throughout the experiment. Absence of clinical and behavioral signs observed in the present study is may be due to low dose of tartrazine used in the study which was not sufficient enough to produce any clinical signs.

Mortality

No mortality was noticed in any group of rats throughout the study period.

Body weight

The average body weight gram (g) of all the male and female rats were measured weekly till day 90 of the experiment and are presented in Table 1 and 2, respectively. There was no significant change in body weight of male and female rats belonging to Group II, Group III and Group IV as compared to Group I at the end of 7th, 14th, 21th, 28th, 35th, 42th, 49th, 56th, 63th, 70th, 77th, 84th and 91th day respectively. Body weight of rats in the treatment groups did not show any significant changes as compared to control group.

Haematological profile

Hematological parameters of all the male and female rats of groups I to IV were studied on 91st day of experiment and are presented in Table 1 and 2.

Table 1: Effect of tartrazine on haematological parameters (Mean ± S.D., n = 10) in male rats after daily oral administration for 90 days

Parameter	Unit	Group I Control	Group II (50 mg/kg)	Group III (100 mg/kg)	Group IV (200 mg/kg)
TLC / WBC	10^3/µL	16.05 ± 4.45	20.07 ± 3.39	18.38 ± 4.68	16.98 ± 2.71
Lymphocytes	10^3/µL	10.41 ± 2.83	14.44* ± 2.46	13.97* ± 3.47	13.56* ± 2.41
Monocytes	10^3/µL	0.62 ± 0.24	0.65 ± 0.21	0.70 ± 0.21	0.54 ± 0.13
Neutrophils	10^3/µL	4.62 ± 1.40	4.45* ± 0.87	3.26* ± 1.02	2.48* ± 0.58
Eosinophils	10^3/µL	0.46 ± 0.20	0.47 ± 0.08	0.46 ± 0.16	0.41 ± 0.13
Basophils	10^3/µL	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Haemoglobin	g/dL	14.67 ± 0.78	14.80 ± 0.57	15.20 ± 0.51	14.46 ± 0.69
HCT	%	37.61 ± 2.10	36.58 ± 1.99	36.41 ± 1.37	37.32 ± 1.89
TEC / RBC	10^6/ µL	7.19 ± 0.41	7.32 ± 0.38	7.45 ± 0.25	7.12 ± 0.52
MCV	fL	52.28 ± 2.33	50.48 ± 1.93	50.09 ± 2.30	51.90 ± 2.51
MCHC	g/dL	40.03 ± 1.23	39.62 ± 1.90	40.17 ± 2.03	39.11 ± 1.57
MCH	Pg	20.41 ± 0.48	20.21 ± 0.61	20.42 ± 0.55	20.39 ± 0.77
PLT	10^3/µL	659.20 ± 85.85	630.10 ±123.75	595.60 ±112.24	645.50 ±160.38
MPV	fL	6.41 ± 0.48	5.88 ± 0.33	6.11 ± 0.51	6.03 ± 0.38

*Significant (P<0.05)

Table 2: Effect of tartrazine on haematological parameters (Mean ± S.D., n = 10) in female rats after daily oral administration for 90 day

Parameter	Unit	Group I Control	Group II (50 mg/kg)	Group III (100 mg/kg)	Group IV (200 mg/kg)
TLC / WBC	10^3/µL	13.06 ± 2.99	13.74 ± 2.65	12.29 ± 3.77	13.06 ± 2.35
Lymphocytes	10^3/µL	8.38 ± 1.79	10.26* ± 1.43	9.47* ± 3.06	10.06* ± 1.65
Monocytes	10^3/µL	0.50 ± 0.17	0.49 ± 0.13	0.36 ± 0.10	0.42 ± 0.09
Neutrophils	10^3/µL	3.79± 0.99	2.65* ± 1.32	2.16* ± 0.81	2.25* ± 0.88
Eosinophils	10^3/µL	0.36 ± 0.11	0.34 ± 0.09	0.30 ± 0.08	0.33 ± 0.08
Basophils	10^3/µL	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Haemoglobin	g/dL	14.82 ± 1.37	14.23 ± 2.47	15.54 ± 1.07	14.51 ± 0.54
HCT	%	40.07 ± 2.53	35.87 ± 7.41	39.93 ± 2.75	37.74 ± 1.57
TEC / RBC	10^6/ µL	7.17 ± 0.40	6.73 ± 1.20	7.53 ± 0.52	7.26 ± 0.49
MCV	fL	52.28 ± 2.33	52.95 ± 2.58	53.02 ± 1.61	51.85 ± 2.15
MCHC	g/dL	39.05 ± 1.22	40.08 ± 2.27	38.93 ± 0.72	39.04 ± 0.89
MCH	Pg	20.41 ± 0.48	20.74 ± 0.92	20.64 ± 0.54	20.40 ± 0.71
PLT	10^3/µL	934.90 ± 89.85	924.60 ±136.07	905.80 ±223.36	782.90 ±139.03
MPV	fL	8.00 ± 0.64	7.49 ± 1.12	7.26 ± 0.97	8.27 ± 0.73

*Significant (P<0.05)

In the present study, there were no any statistically significant difference in the haematology data of TLC, Monocyte, Eosinophile, Basophile, Haemoglobin, HCT, TEC, MCV, MCHC, MCH, PLT and MPV in male and female group treated with tartrazine.

The Mean ± S.D. values of lymphocytes (10^3/µL) in male and female rats of Groups I, II, III and IV were 10.41 ± 2.83, 14.44 ± 2.46, 13.97 ± 3.47, 13.56 ± 2.41 and 8.38 ± 1.79, 10.26 ± 1.43, 9.47 ± 3.06, 10.06 ± 1.65 respectively. The male and female rats of Groups II, III and IV revealed significant (P < 0.05) increase in lymphocyte value when compared to control rats.

The results of the present study in terms of lymphocyte values were in accordance with the Sharma *et al*. (2009) [12] and Golli *et al*. (2016) [13]. Sharma *et al*. (2009) [12] administered tartrazine to Swiss albino mice at dose of 200 and 400 mg/kg b. wt. for 35 days and noticed increased value of lymphocytes in treatment groups when compared to control groups.

Similarly Golli *et al*. (2016) [13] have given tartrazine to Wistar rats at dose of 300 mg/kg b. wt. for 30 days and found increased lymphocyte count in treatment group when compared with control group.

The findings of the present study were in contrary to the findings of Himari *et al*. (2011) [14] in which they administered tartrazine to Wistar rats at dose of 5, 7.5 and 10 mg/kg b. wt. for 90 days and they found decrease in the value of lymphocytes in treatment group when compared with control group animals.

The Mean ± S.D. values of neutrophils (10^3/µL) in male and rats of Groups I, II, III and IV were 4.62 ± 1.40, 4.45 ± 0.87, 3.26 ± 1.02, 2.48 ± 0.58 and3.79 ± 0.99,2.65 ± 1.32, 2.16 ± 0.81, 2.25 ± 0.88 respectively. The male and female rats of Groups II, III and IV revealed significant (P < 0.05) decrease in neutrophils value when compared to control rats.

The findings of the present study were in agreement with the findings of Sharma *et al*. (2009) [12] in terms of neutrophils value in which the authors administered tartrazine to Swiss albino mice at dose of 200 and 400 mg/kg b. wt. for 35 days and noticed significantly decreased value of neutrophils in treatment groups when compared with control group.

The findings of the present study were not in agreement with that of Himari *et al*. (2011) [14]. They administered tartrazine to Wistar rats at dose of 5, 7.5 and 10 mg/kg b. wt. for 90 days and found significant increase in neutrophils value in treatment group when compared to control group animals.

Biochemical profile

Biochemical parameters of all the male and female rats belonging to Group I to Group IV was studied with daily oral administration of tartrazine for 90 days. The estimation of different biochemical parameters was carried out on 91st day of experiment and presented in Table 3 and 4.

Table 3: Effect of tartrazine on biochemical parameters (Mean ± S.D., n = 10) in male rats after daily oral administration for 90 days

Parameter/Unit	Group I Control	Group II (50 mg/kg)	Group III (100 mg/kg)	Group IV (200 mg/kg)
Alanine Aminotransferase (ALT) (U/L)	52.00 ± 6.76	62.88* ± 10.38	70.33* ± 10.36	85.11* ± 7.81
Aspartate Aminotransferase (AST) (U/L)	160.18 ± 32.38	194.48* ± 20.39	239.86* ± 29.88	251.83* ± 27.09
Alkaline Phosphatase (ALP)(U/L)	184.31 ± 65.81	243.94* ± 62.30	252.36* ± 44.01	265.16* ± 24.37
Gamma Glutamyl Transferase (GGT)(U/L)	12.00 ± 2.30	14.50* ± 2.12	15.50* ± 1.35	16.10* ± 1.79
Total Protein (g/dL)	7.94 ± 0.92	7.43 ± 0.86	6.40 ± 1.79	7.19 ± 1.41
Albumin (g/dL)	2.86 ± 0.21	2.77 ± 0.21	2.67 ± 0.23	2.60 ± 0.36
Urea (mg/dL)	60.79 ± 7.14	61.01 ± 9.91	63.03 ± 16.16	52.73 ± 12.38
Creatinine (mg/dL)	0.69 ± 0.05	0.61 ± 0.08	0.57 ± 0.14	0.63 ± 0.11
Triglycerides (mg/dL)	106.93 ± 22.69	96.11 ± 26.19	78.26 ± 30.67	93.85 ± 34.67
Cholesterol (mg/dL)	41.50 ± 17.99	49.97 ± 11.12	46.29 ± 7.33	56.10 ± 7.17
Glucose mg/dL)	77.68 ± 5.66	73.19 ± 8.35	74.36 ± 8.64	69.50 ± 7.13
Magnesium (mg/dL)	2.88 ± 0.33	2.65 ± 0.33	2.76 ± 0.37	2.81 ± 0.59
Calcium (mg/dL)	9.37 ± 0.81	10.03 ± 0.61	9.71 ± 0.71	9.40 ± 0.48
Phosphorus (mg/dL)	4.97 ± 0.45	4.95 ± 0.25	4.79 ± 0.40	4.77 ± 0.45
Iron (µg/dL)	174.57 ± 34.76	170.36 ± 36.87	169.15 ± 26.74	168.23 ± 28.03

*Significant (P<0.05)

In the present study, Albumin, Urea, Creatinine, Triglycerides, Cholesterol, Glucose, and along with minerals such as Magnesium, Calcium, Phosphorus and Iron did not altered significantly. In case of groups of male treated with tartrazine did not reveal significant in Total protein.

The Mean ± S.D. values of ALT (U/L) in male and female rats of Groups I, II, III and IV were 52.00 ± 6.76, 62.88 ± 10.38, 70.33 ± 10.36, 85.11 ± 7.81 and 55.13 ± 6.55, 65.72 ± 10.19, 71.87 ± 11.25, 88.53 ± 6.33 respectively. The rats of Groups II, III and IV revealed significant ($P < 0.05$) increase in the value of ALT when compared with control group rats. The results of the present study were in accordance with the Al-shinnawy and Elkattan (2013) [15], Ali *et al*. (2016) [16], Goli *et al*. (2016) [13] and Khayyat *et al*. (2017) [17].

Table 4: Effect of tartrazine on biochemical parameters (Mean ± S.D., n = 10) in female rats after daily oral administration for 90 days

Parameter/Unit	Group I Control	Group II (50 mg/kg)	Group III (100 mg/kg)	Group IV (200 mg/kg)
Alanine Aminotransferase (ALT) (U/L)	55.13 ± 6.55	65.72* ± 10.19	71.87* ± 11.25	88.53* ± 6.33
Aspartate Aminotransferase (AST) (U/L)	149.37 ± 28.24	184.95* ± 18.11	229.75* ± 27.89	236.51* ± 42.24
Alkaline Phosphatase (ALP)(U/L)	223.50 ± 42.18	280.78* ± 56.32	297.48* ± 34.40	308.35* ± 39.79
Gamma Glutamyl Transferase (GGT)(U/L)	14.17 ± 1.68	16.72* ± 2.00	17.88* ± 2.10	18.18* ± 1.60
Total Protein (g/dL)	8.57 ± 0.32	9.01* ± 0.30	9.49* ± 0.53	10.35* ± 0.35
Albumin (g/dL)	3.63 ± 0.30	3.55 ± 0.35	3.56 ± 0.23	3.59 ± 0.19
Urea (mg/dL)	72.63 ± 4.04	71.13 ± 11.54	72.03 ± 6.63	76.94 ± 9.47
Creatinine (mg/dL)	0.91 ± 0.07	0.85 ± 0.02	0.86 ± 0.05	0.88 ± 0.05
Triglycerides (mg/dL)	103.54 ± 21.29	91.95 ± 23.60	75.27 ± 24.64	85.64 ± 23.44
Cholesterol (mg/dL)	43.91 ± 23.08	45.97 ± 15.72	42.13 ± 14.08	55.73 ± 9.17
Glucose mg/dL)	70.70 ± 6.71	64.20 ± 5.80	67.20 ± 3.45	65.70 ± 10.67
Magnesium (mg/dL)	3.50 ± 0.38	3.20 ± 0.40	3.44 ± 0.56	3.37 ± 0.29
Calcium (mg/dL)	9.43 ± 0.71	9.17 ± 0.54	9.18 ± 0.94	9.13 ± 0.97
Phosphorus (mg/dL)	4.78 ± 0.36	4.48 ± 0.43	4.70 ± 0.41	4.82 ± 0.38
Iron (µg/dL)	177.43 ± 34.85	173.40 ± 36.77	164.88 ± 27.71	166.77 ± 25.36

*Significant ($P<0.05$)

The Mean ± S.D. values of AST (U/L) in male and female rats of Groups I, II, III and IV were 160.18 ± 32.38, 194.48 ± 20.39, 239.86 ± 29.88, 251.83 ± 27.09 and 149.37 ± 28.24, 184.95 ± 18.11, 229.75 ± 27.89, 236.51 ± 42.24 respectively. The rats of Groups II, III and IV revealed significant ($P < 0.05$) increase in value of AST when compared with that of the control rats.

The findings of the present study were in agreement with the findings of Himari *et al*. (2011) [14], Al-shinnawy and Elkattan (2013) [15], Ali *et al*. (2016) [16], Goli *et al*. (2016) [13], Khayyat *et al*. (2017) [17] and Elekima *et al*. (2019) [18]. They are reported significantly higher value of AST in treatment groups when compared with that of control groups.

The Mean ± S.D. values of ALP (U/L) in male and female rats of Groups I, II, III and IV were 184.31 ± 65.81, 243.94 ± 62.30, 252.36 ± 44.01, 265.16 ± 24.37 and 223.50 ± 42.18, 280.78 ± 56.32, 297.48 ± 34.40, 308.35 ± 39.79 respectively. The male rats of Groups II, III and IV revealed significant ($P < 0.05$) increase in the value of ALP when compared to control rats.

The findings of the present study in terms of ALP were in agreement with the Sharma *et al*. (2009), Al-shinnawy and Elkattan (2013) [15], Saxena and Sharma (2015) [19], Goli *et al*. (2016) [13], Khayyat *et al*. (2017) [17], Elekima *et al*. (2019) [18] and Meena and Meena (2020) [20]. All the studies revealed a higher value of ALP in treatment groups when compared with control groups.

The Mean ± S.D. values of GGT (U/L)) in male and female rats of Groups I, II, III and IV were 12.00 ± 2.30, 14.50 ± 2.12, 15.50 ± 1.35, 16.10 ± 1.79 and14.17 ± 1.68, 16.72 ± 2.00, 17.88 ± 2.10, 18.18 ± 1.60 respectively. The male rats of Groups II, III and IV revealed a significant ($P < 0.05$) increase in the value of GGT when compared to control rats.

The outcomes of the present study were in agreement with the Al-shinnawy and Elkattan (2013) [15], Khayyat *et al*. (2017) [17] and Elekima *et al*. (2019) [19]. They found significantly higher value of GGT in treated groups of experimental animals when compared with control groups as in the present study.

The Mean ± S.D. values of TP (g/dL) were 8.57 ± 0.32, 9.01 ± 0.30, 9.49 ± 0.53 and 10.35 ± 0.35 in female rats of Groups I, II, III and IV, respectively. The rats of Groups II, III and IV showed a significant ($P < 0.05$) increase in the value of TP when compared with that of the control group rats.

The findings of the present study were in accordance with the Sharma *et al*. (2009), Himari *et al*. (2011) [14], Al-shinnawy and Elkattan (2013) [15], Ali *et al*. (2016) [16], Goli *et al*. (2016) [13] and Elekima *et al*. (2019) [19] in which the authors reported significantly higher values of total protein in treatment groups of experimental animals when compared with control groups.

Conclusions

Tartrazine is an aromatic azo group synthetic food dye which is widely used in food industry to give better colouring of foods as easy way and cost effectively than natural colour. Oral administration of tartrazine in Wistar rats @ 50, 100 and 200 mg/kg b. wt. did not produce any noticeable symptoms and clinical as well as behavioural signs throughout the experimental period of 90 days. Haematological parameters revealed significant ($P < 0.05$) increase in lymphocytes values and decrease in neutrophils values in all treated groups of both sex in Wistar rats. Tartrazine produced alterations in biochemical profile as evident by significant ($P < 0.05$) increase in ALP, ALT, AST, GGT in all treated groups of both sex whereas total protein was significantly ($P < 0.05$) higher in treated groups of only female rats.

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