RESULTS

Hematological parameters:

Table (1) and Figures (1 and 2) illustrated the hematological parameters of control rats group (group I), rats group supplemented with vitamins C and E (group II), STZ-diabetic rats group (group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (group IV) and rats group supplemented with vitamin C and E post STZ-diabetic induction (group V).

WBCs count showed significant increase ($P < 0.01$) in group II and significant decrease ($P < 0.05$) in group III related to that of the group I. WBC_S count in group III showed significant decrease ($P < 0.05$) compared to that of the group II. WBCs count in group IV and V showed significant increases ($P < 0.05$) compared to that of the group III (Table 1 & Fig. 1-1).

RBCs count showed non significant decreases in all treated groups compared to that of the group I (Table 1 & Fig. 1-2).

Blood hemoglobin (Hb) concentration showed non significant decreases in all treated groups compared to that of the group I (Table 1 & Fig. 1-3).

Hematocrit value (Hct) significantly increased ($P < 0.05$) in group II in relation to those of group I. Hematocrit value significantly decreased ($P < 0.05$, $P < 0.01$ & $P < 0.05$) in group III, group IV and group V respectively compared to that of the group II (Table 1 & Fig. 1-4).

MCV decreased significantly ($P < 0.05$) in group III and group IV compared to that of the group II (Table 1 & Fig. 2-1).

Table (1): Hematological parameters of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / *Parameters*	Group I	Group II	Group III	Group IV	Group V	P
WBCs ($\times 10^3$ cells/mm^3)	8.72 ± 0.39	$9.30 \pm 0.20^{@**}$	$7.50 \pm 0.40^{@*\alpha*}$	$8.47 \pm 0.25^{\beta*}$	$8.48 \pm 0.15^{\beta*}$	***
RBCs ($\times 10^6$ cells/mm^3)	6.31 ± 0.44	6.18 ± 0.12	5.68 ± 0.63	5.51 ± 0.39	5.50 ± 0.46	N.S
Hb (g/dl)	12.43 ± 0.30	12.8 ± 0.10	11.47 ± 1.01	11.8 ± 0.30	11.93 ± 0.06	N.S
Hct (%)	40.50 ± 0.50	$42.33 \pm 0.60^{@*}$	$39.83 \pm 0.15^{\alpha*}$	$39.78 \pm 0.45^{\alpha**}$	$40.50 \pm 0.87^{\alpha*}$	*
MCV (μ^3)	61.16 ± 0.85	62.00 ± 0.10	$59.83 \pm 0.76^{\alpha*}$	$59.73 \pm 0.45^{\alpha*}$	60.26 ± 0.21	**
MCH (pg)	20.27 ± 0.25	20.14 ± 0.55	20.13 ± 0.50	20.13 ± 0.15	20.10 ± 0.01	N.S
MCHC (g/dl)	32.50 ± 0.40	32.67 ± 0.15	$31.90 \pm 0.10^{\alpha**}$	$31.97 \pm 0.25^{\alpha*}$	$31.97 \pm 0.11^{\alpha*}$	**
Platelets ($\times 10^3$ cells/mm^3)	610.00 ± 9.89	575.00 ± 5.86	$614.50 \pm 0.71^{\alpha*}$	$606.00 \pm 4.24^{\alpha*}$	$608.00 \pm 4.24^{\alpha*}$	**

All data expressed as mean ± SD
*: Significant difference at P < 0.05 @: refers to the relation of the groups with group I
**: Significant difference at P < 0.01 α: refers to the relation of the group III or group IV or group V with group II
***: Significant difference at P < 0.001 β: refers to the relation of group IV or group V with Group III
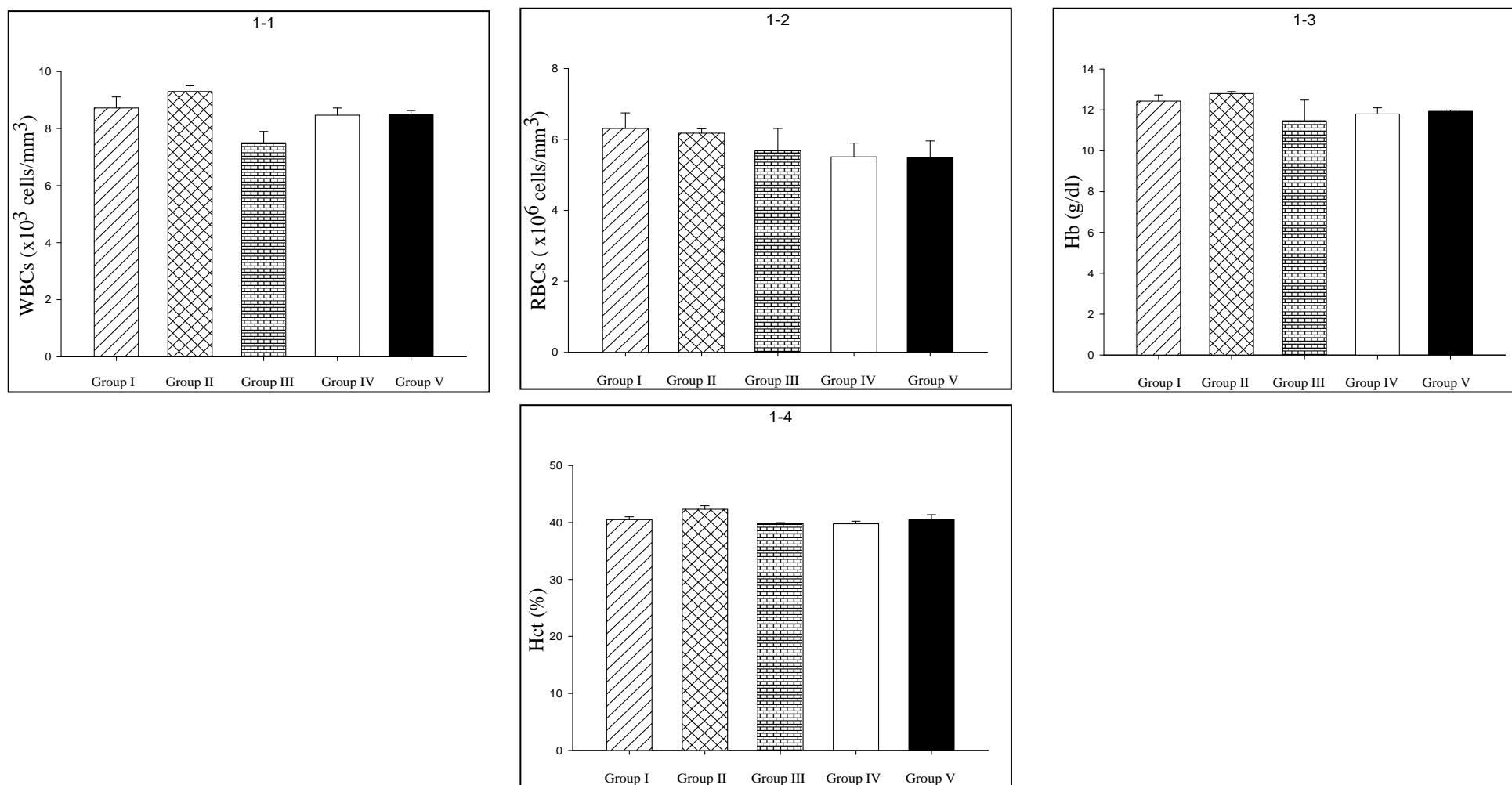
Figure (1): Hematological parameters of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).
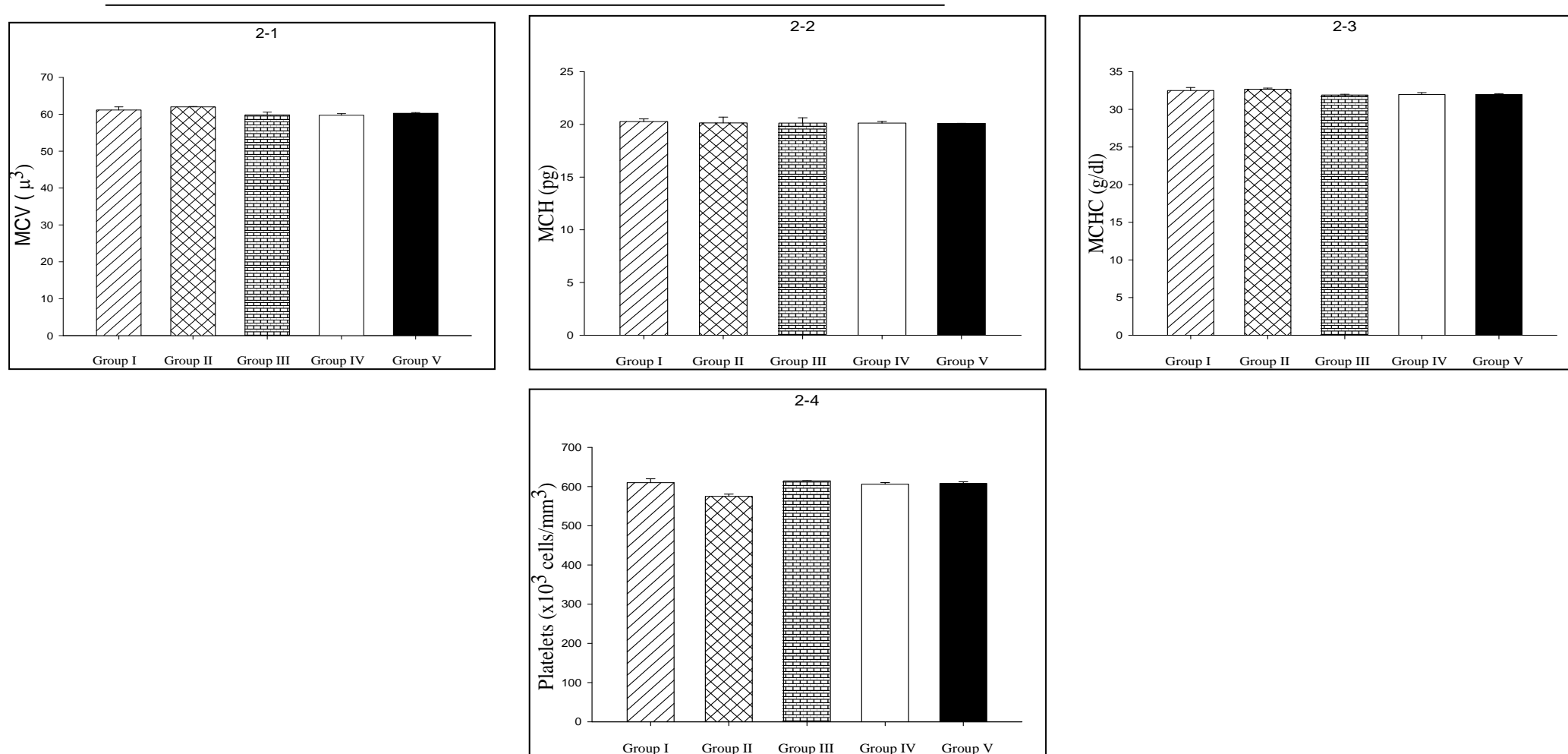
Figure (2): Blood indices and Platelets count of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

MCH showed non significant decreases in all treated groups compared to that of the group I (Table 1 & Fig. 2-2).

MCHC was decreased significantly (P < 0.01, P < 0.05 & P < 0.05) in group III, group IV and group V respectively compared to that of the group II (Table 1 & Fig. 2-3).

Platelets count showed significant increases (P < 0.05) in group III, group IV and group V compared to that of the group II (Table 1 & Fig. 2-4).

Respiratory functions of blood:

I. Blood gases:

1. Blood oxygen partial pressure (PO_2):

Arterial blood PO_2 (P_aO_2) of rats group supplemented with vitamins C and E (group II) and the STZ-diabetic rats group (group III) increased significantly (P < 0.05 & P < 0.01, respectively) compared to those of the control rats group (group I). P_aO_2 values of the rats groups supplemented with vitamins C and E before or post STZ-diabetic induction (group IV and group V, respectively) decreased significantly (P < 0.05) compare to that of the STZ-diabetic rats group (group III).

Venous blood PO_2 (P_vO_2) of the rats group supplemented with vitamins C and E (group II) showed significant increases (P < 0.01) compared to those of the control rats group (group I). The STZ-diabetic rats group (group III) and the rats group supplemented with vitamins C and E post STZ-diabetic induction (group V) showed significant decreases (p < 0.05) in P_vO_2 compared to that of the group II (Table 2 & Fig.3-1).

Table (2): Blood gases of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / *Parameters*		Group I	Group II	Group III	Group IV	Group V	P
PO$_2$	a	75.67 ± 8.62	$102.00 \pm 7.81^{@*}$	$119.67 \pm 8.39^{@**}$	$94.33 \pm 9.50^{\beta*}$	$88.00 \pm 1.39^{\beta*}$	**
(mm Hg)	v	44.25 ± 3.5	$59.67 \pm 4.04^{@**}$	$45.33 \pm 4.04^{\alpha*}$	42.00 ± 11.36	$44.00 \pm 8.00^{\alpha*}$	*
Blood O$_2$	a	97.57 ± 0.21	96.57 ± 0.71	$98.00 \pm 0.52^{\alpha*}$	97.23 ± 0.85	$96.27 \pm 0.40^{@*\beta*}$	*
Saturation(%)	v	78.13 ± 3.92	87.11 ± 4.16	80.17 ± 4.91	79.30 ± 4.48	75.17 ± 8.26	N.S
PCO$_2$	a	39.67 ± 0.58	$34.25 \pm 1.76^{@*}$	$35.75 \pm 0.35^{@*}$	$40.50 \pm 0.70^{\alpha**\beta*}$	$27.50 \pm 0.70^{@***\alpha**\beta**\delta**}$	***
(mm Hg)	v	45.00 ± 2.00	45.00 ± 2.00	49.67 ± 4.61	$54.00 \pm 2.08^{@*\alpha*}$	$51.33 \pm 2.08^{@*\alpha*}$	*

All data expressed as mean ± SD
*: Significant difference at P < 0.05   @: refers to the relation of the groups with group I
**: Significant difference at P < 0.01   α: refers to the relation of the group III or group IV or group V with group II
***: Significant difference at P < 0.001   β: refers to the relation of group IV or group V with Group III
                                                δ: refers to the relation of group V and group IV

a =arterial blood
v = venous blood

2. Blood oxygen saturation:

There was a significant decrease (P < 0.05) in arterial blood oxygen saturation (%) of the rats group supplemented with vitamins C and E post STZ-diabetic induction (group V) compared to that of the control rats group (group I). The STZ-diabetic rats group (group III) showed significant increase (p < 0.05) in arterial blood oxygen saturation (%) than that of rats group supplemented with vitamins C and E (group II). Rats group supplemented with vitamins C and E post STZ-diabetic induction (group V) showed significant decreases (P < 0.05) in arterial blood oxygen saturation (%) compared to that of the STZ-diabetic rats group.

Venous blood oxygen saturation (%) showed non significant decreases in all treated groups compared to that of the control group (Table 2 & Fig. 3-2).

3. Blood carbon dioxide partial pressure (PCO_2):

Rats group supplemented with vitamins C and E (group II), STZ-diabetic rats group (group III) and rats group supplemented with vitamins C and E post STZ-diabetic induction (group V) showed significant decreases (P < 0.05, P < 0.05 & P < 0.001, respectively) in arterial blood PCO_2 (P_aCO_2) in comparison with that of the control rats group (group I). P_aCO_2 of rats groups supplemented with vitamins C and E before or post STZ-diabetic induction showed a significant increase and decrease (P < 0.01) respectively compared to rats group supplemented with vitamins C and E. P_aCO_2 of rats group supplemented with vitamins C and E before or post STZ-diabetic induction were
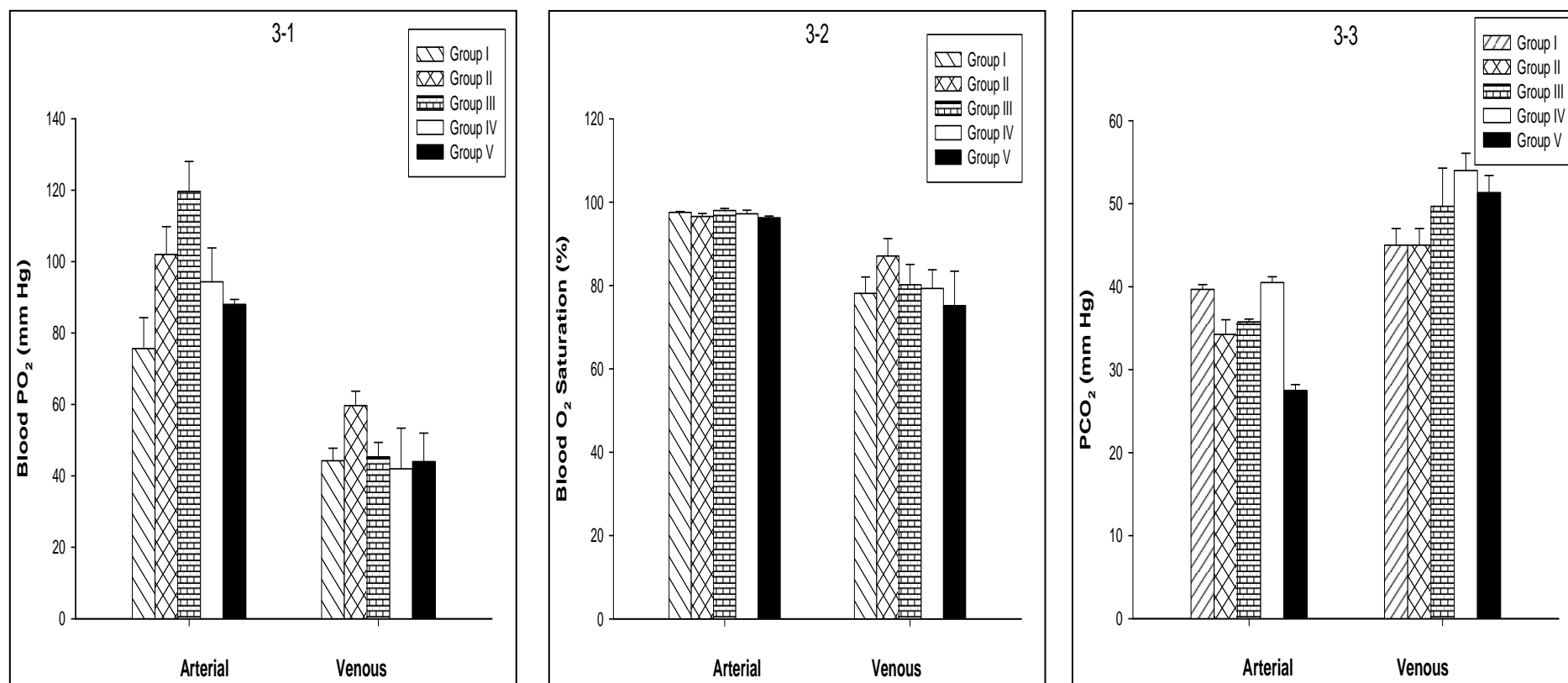
Figure (3): Blood gases of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

significantly increased and decreased (P < 0.05 and p < 0.01, respectively) compared to that of the STZ-diabetic rats group. Rats group supplemented with vitamins C and E post STZ-diabetic induction was significantly decreased (p < 0.01) compared to that of the rats group supplemented with vitamins C and E before STZ-diabetic induction.

Venous blood PCO_2 (P_vCO_2) was significantly increased (P < 0.05) in rats groups supplemented with vitamins C and E before or post STZ-diabetic induction (groups IV and group V) in relation to control rats group (group I). Rats group supplemented with vitamins C and E before or post STZ-diabetic induction showed significant increase (P < 0.05) in P_vCO_2 in comparison with those of the rats group supplemented with vitamins C and E before (Table 2 & Fig. 3-3).

II. Blood acid-base status parameters:

1. Blood pH:

Arterial blood pH of the rats group supplemented with vitamins C and E (group II) and STZ-diabetic rats group (group III) showed significant decreases (P < 0.05) compared to that of the control rats group (group I).

Venous blood pH of the STZ-diabetic rats group (group III) showed a significant increase (P < 0.05) in relation to that of the rats group supplemented with vitamins C and E (Table 3 & Fig. 4-1).

2. Blood bicarbonate (HCO_3^-):

Arterial blood HCO_3^- concentration of rats' group supplemented with vitamins C and E (group II) was significantly decreased (P < 0.05) compared to that of the control rats group (group I). Rats group supplemented with vitamins C and E before STZ-diabetic induction was

Table (3): Acid-base status of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / Parameters		Group I	Group II	Group III	Group IV	Group V	P
pH	a	7.47 ± 0.09	$7.26 \pm 0.08^{@*}$	$7.25 \pm 0.06^{@*}$	7.34 ± 0.07	7.32 ± 0.07	N.S
	v	7.23 ± 0.07	7.23 ± 0.04	$7.33 \pm 0.03^{\alpha*}$	7.30 ± 0.05	7.29 ± 0.03	N.S
HCO_3^- (mmol/l)	a	21.85 ± 2.49	$15.93 \pm 2.25^{@*}$	18.50 ± 0.36	$20.33 \pm 1.30^{\alpha*}$	18.40 ± 4.55	N.S
	v	26.80 ± 2.54	22.88 ± 1.73	$29.93 \pm 0.81^{\alpha**}$	25.97 ± 2.39	25.17 ± 2.40	*
TCO_2 (mmol/l)	a	24.43 ± 0.32	$16.77 \pm 2.45^{@**}$	21.23 ± 3.18	23.37 ± 3.82	19.50 ± 4.70	N.S
	v	28.27 ± 1.88	$22.10 \pm 1.73^{@*}$	$31.77 \pm 1.21^{\alpha**}$	$28.30 \pm 2.84^{\alpha*}$	29.36 ± 6.44	N.S
BE (mmol/l)	a	-6.00 ± 0.66	-9.55 ± 2.55	-5.60 ± 0.99	-4.00 ± 0.85	$-3.20 \pm 0.57^{@*}$	*
	v	-1.75 ± 0.21	-4.15 ± 0.91	$2.45 \pm 0.07^{@**\alpha**}$	$2.60 \pm 1.56^{\alpha*}$	$2.25 \pm 1.48^{\alpha*}$	**

All data expressed as mean ± SD

*: Significant difference at P < 0.05 @: refers to the relation of the groups with group I

**: Significant difference at P < 0.01 α: refers to the relation of the group III or group IV or group V with group II

***: Significant difference at P < 0.001

a =arterial blood

v = venous blood

significantly increased ($p < 0.05$) in arterial blood HCO_3^- concentration than that of the rats group supplemented with vitamins C and E (group II).

Venous blood HCO_3^- concentration of the STZ-diabetic rats group showed a significant increase ($P < 0.01$) compared to that of the rats group supplemented with vitamins C and E (group II) (Table 3 & Fig. 4-2).

3. Blood total carbon dioxide (TCO_2):

It was obvious from the data presented in table (3) and Figure (4-3) that there was a significant decrease ($P < 0.01$) in arterial blood TCO_2 of the rats group supplemented with vitamins C and E (group II) in relation to that of the control rats group (group I).

Venous blood TCO_2 of the rats group supplemented with vitamins C and E was significantly decreased ($p < 0.05$) than that of the control rats group. Venous blood TCO_2 of STZ-diabetic rats group (group III) and rats group supplemented with vitamins C and E before STZ-diabetic induction (group IV) were significantly increased ($P < 0.01$ and $P < 0.05$, respectively) than that of the rats group supplemented with vitamins C and E (group II) (Table 4 & Fig. 4-3).

4. Blood base excess (BE):

Base excess (BE) of the arterial blood showed a significant increase ($P < 0.05$) in rats group supplemented with vitamins C and E post STZ-induction (group V) in comparison to that of the control rats group (group I).
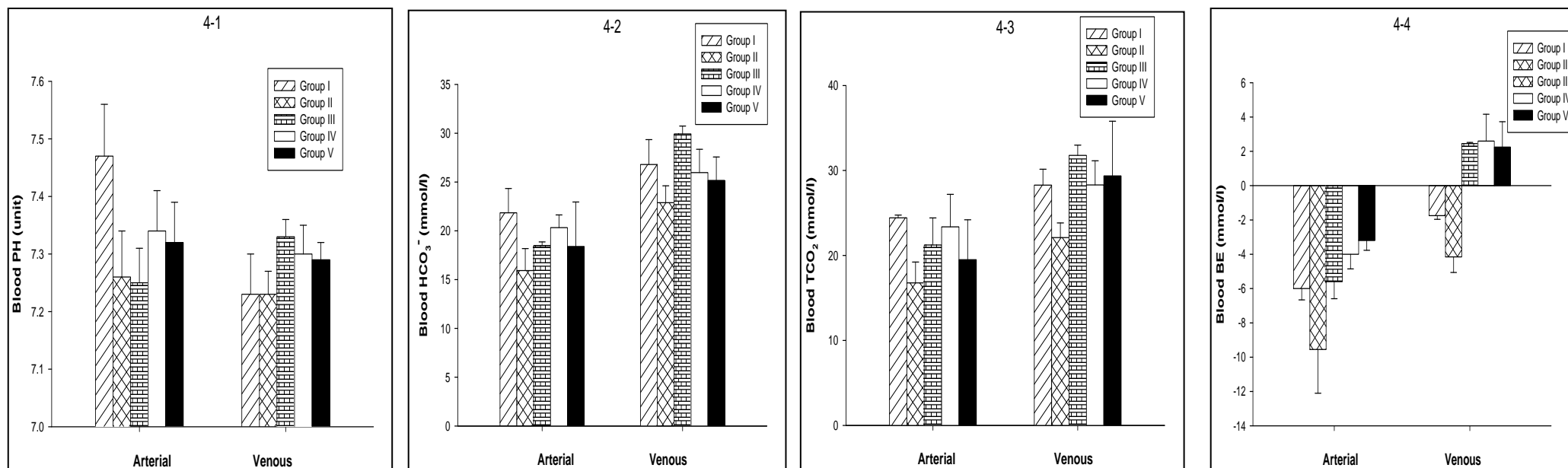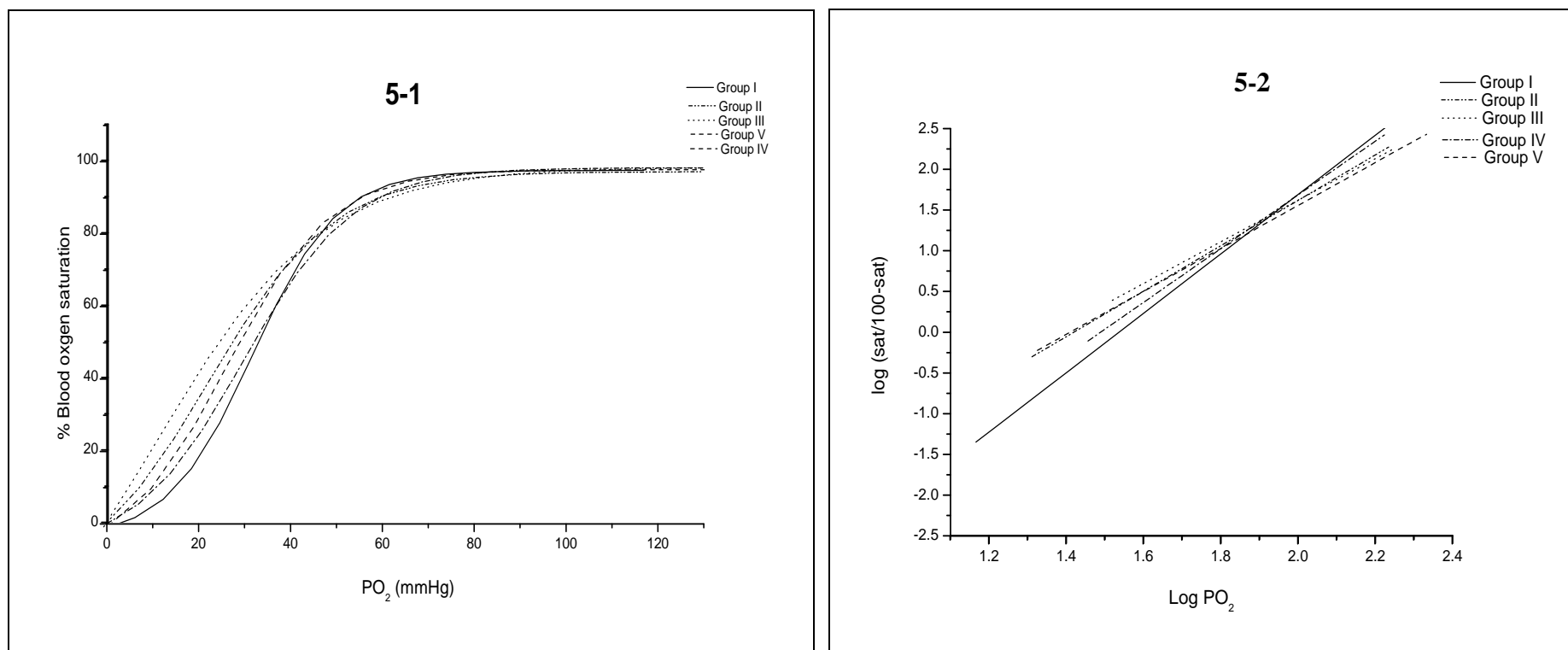
Figure (4): Blood acid-base status parameters and base excess of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Venous blood BE of STZ-diabetic rats group (group III) showed a significant increase (P <0.01) compared to that of the control rats group (group I). Venous blood BE of the STZ-diabetic rats group (group III) and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant increase (P < 0.01, P < 0.05 & P < 0.05, respectively) compared to that of the rats group supplemented with vitamins C and E (group II) (Table 3 & Fig. 4-4).

III. Blood oxygen equilibrium curve (OEC):

The blood OEC of rats group supplemented with vitamins C and E (group II), STZ-diabetic rats group (group III) and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were found to be shifted to the left compared to that of the control rats group (group I).

The blood oxygen half saturation pressure (P_{50}) of rats group supplemented with vitamins C and E (group II) and rats group supplemented with vitamins C and E post STZ-diabetic induction (group V) were significantly lower (P < 0.01 & P < 0.05, respectively) than that of the control rats group (group I). P_{50} of STZ-diabetic rats group (group III) and rats group supplemented with vitamins C and E before STZ-diabetic induction (group IV) was significantly lower (p < 0.05 and P < 0.01, respectively) than that of the rats group supplemented with vitamins C and E (group II). P_{50} of rats group supplemented with vitamins C and E post STZ-diabetic induction was significantly lower (P < 0.05) than that of the STZ-diabetic rats group and rats group supplemented with vitamins C and E before STZ-diabetic induction (Table4&Fig.5-1).

Figure (5): The blood oxygen equilibrium curves and Hill's Plot of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Table (4): The blood oxygen half pressure (P_{50}) and Hill's constants (n values) of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ- diabetic induction (Group V).

Rat groups / Parameters	Group I	Group II	Group III	Group IV	Group V	P
P_{50} (mmHg)	33.95 ± 0.17	$22.39 \pm 0.65^{@**}$	$30.20 \pm 0.36^{\alpha*}$	$33.09 \pm 0.33^{\alpha**}$	$25.27 \pm 0.97^{@**\beta*\delta*}$	*
n	3.64 ± 0.13	$2.16 \pm 0.08^{@**}$	$2.05 \pm 0.08^{@**}$	$2.86 \pm 0.12^{@*}$	$2.06 \pm 0.1^{@**}$	***

All data expressed as mean ± SD

*: Significant difference at $P < 0.05$ @: refers to the relation of the groups with group I

**: Significant difference at $P < 0.01$ α: refers to the relation of the group III or group IV or group V with group II

***: Significant difference at $P < 0.001$ β: refers to the relation of group IV or group V with Group III

δ: refers to the relation of group V and group IV

Hill's constant (n-value in Hill's equation) was significantly decreased (P < 0.01, P < 0.01, P < 0.05 & P < 0.01) in rats supplemented with vitamins C and E (group II), STZ-diabetic rats group (group III) and rats groups supplemented with vitamins C and E before or post STZ-diabetic induction (groups IV and V) respectively compare to control rats group (group I) (Table 4 and Fig. 5-2).

Biochemical parameters:

- **Antioxidants:**

Plasma catalase activities of rats group supplemented with vitamins C and E (group II), STZ-diabetic rats group (group III) and rats groups supplemented with vitamins C and E before or post STZ-diabetic induction (groups IV and V) showed significant increases (P < 0.05, P < 0.001, P < 0.001 & P < 0.001, respectively) compared to that of the control rats group (group I). Plasma catalase activities of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant increase (P < 0.001) compared to that of the rats group supplemented with vitamins C and E (group II). Plasma catalase activities of rat groups supplemented with vitamins C and E before or post STZ-diabetic induction was significantly decreased (P < 0.001) compared to those of the STZ-diabetic rats group (Table 5 & Fig. 6-1).

Plasma superoxide dismutase activities of rats group supplemented with vitamins C and E, STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant decreases (P < 0.05, P < 0.001, P < 0.001 & P < 0.001, respectively) compared to that of the control rats group.

Table (5): Plasma antioxidant enzyme activities (catalase, CAT and superoxide dismutase, SOD) and reduced glutathione concentration (GSH) of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups Parameters	Group I	Group II	Group III	Group IV	Group V	P
Catalase (unit/mI)	611.51 ± 0.32	620.62 ± 0.32$^{@*}$	817.30 ± 1.12$^{@***\alpha***}$	732.45 ± 0.12$^{@***\alpha***\beta***}$	734.34 ± 1.01$^{@***\alpha***\beta***}$	***
SOD (unit/mI)	32.48 ± 0.52	31.62 ± 0.12$^{@*}$	22.50 ± 0.14$^{@***\alpha***}$	25.47 ± 0.10$^{@***\alpha***\beta***}$	24.81 ± 0.21$^{@***\alpha***\beta***}$	**
GSH (mg/mI)	2.73 ± 0.21	2.75 ± 0.10$^{@*}$	2.27 ± 0.02$^{@***\alpha***}$	2.31 ± 0.05$^{@***\alpha***\beta***}$	2.33 ± 0.08$^{@***\alpha***\beta***}$	***

All data expressed as mean ± SD
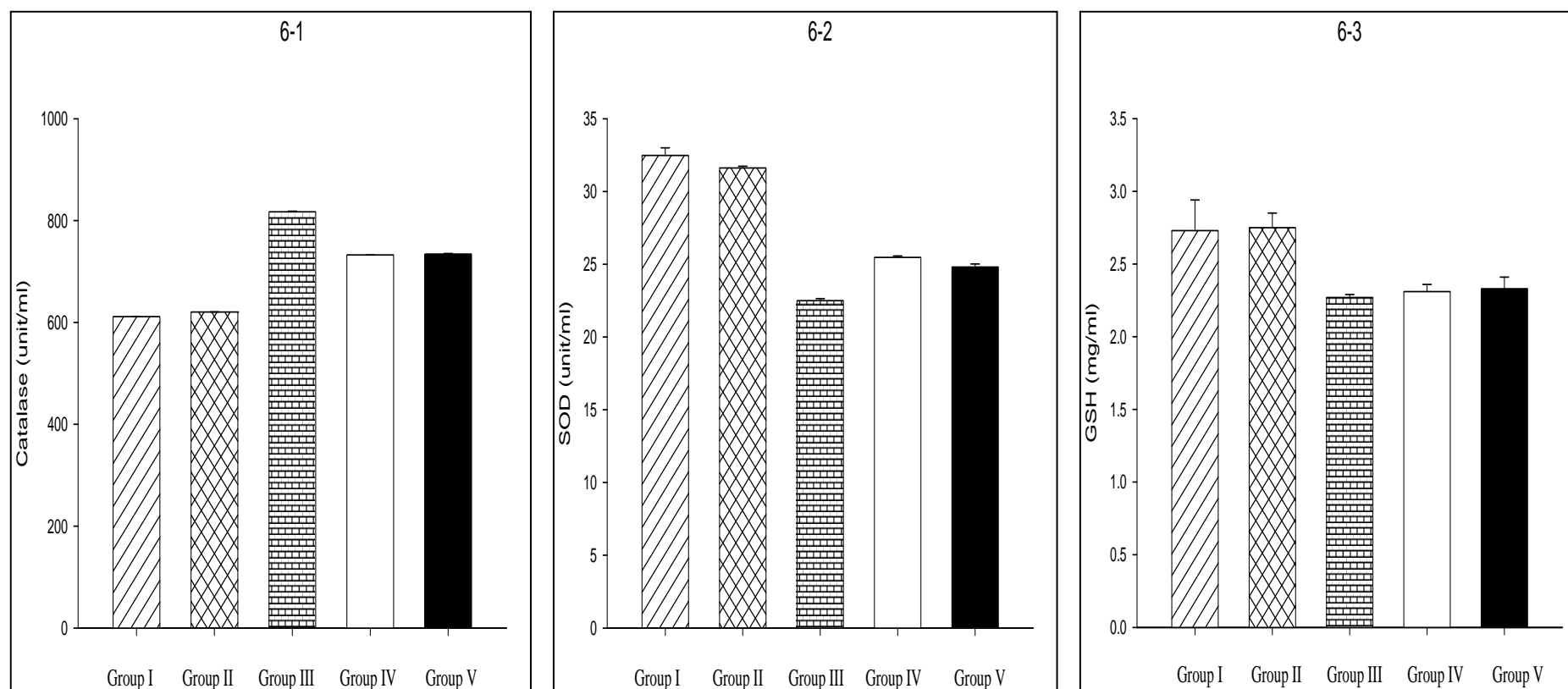
*: Significant difference at $P < 0.05$

**: Significant difference at $P < 0.01$

***: Significant difference at $P < 0.001$

@: refers to the relation of the groups with group I

α: refers to the relation of the group III or group IV or group V with group II

β: refers to the relation of group IV or group V with Group III

Figure (6): Plasma antioxidant enzymes [catalase (6-1) and superoxide dismutase, SOD (6-2)] activity and reduced glutathione, GSH concentrations (6-3) of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

The superoxide dismutase activities of STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant decreases ($P < 0.001$) compared to that of the rats group supplemented with vitamin C and E. Superoxide dismutase activities of rat groups supplemented with vitamins C and E before or post STZ-diabetic was significantly increased ($P < 0.001$) compared to those of the STZ-diabetic rats group (Table 5 & Fig. 6-2).

Plasma reduced glutathione concentration of rats group supplemented with vitamin C and E (group II) showed significant increase ($p < 0.05$) compared to that of the control rats group. Reduced glutathione concentration of STZ-diabetic rats group (group III), rats groups supplemented with vitamins C and E before or post STZ-diabetic induction (group IV and group V) showed significant decrease ($P < 0.001$) compared to that of the control rats group (group I). The reduced glutathione concentration of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant decrease ($P < 0.001$) compared to that of the rats group supplemented with vitamins C and E. Reduced glutathione concentration of rat groups supplemented with vitamins C and E before or post STZ-diabetic induction was significantly high ($P < 0.001$) compared to that of the STZ-diabetic rats group (Table 5 and Fig. 6-3).

- **Plasma metabolites:**
  - ➢ **Glucose:**

The plasma glucose levels of rats group supplemented with vitamins C and E, STZ-diabetic rats group and rat groups supplemented

Table (6): Plasma glucose concentrations of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / Parameters	Group I	Group II	Group III	Group IV	Group V	P
Glucose (mg/dl)	97.95 ± 0.31	114.76 ± 1.61$^{@***}$	223.91 ± 4.27$^{@***\alpha***}$	142.84 ± 2.22$^{@***\alpha***\beta***}$	140.44 ± 1.11$^{@***\alpha***\beta***}$	***

All data expressed as mean ± SD
*: Significant difference at $P < 0.05$ @: refers to the relation of the groups with group I
**: Significant difference at $P < 0.01$ α: refers to the relation of the group III or group IV or group V with group II
***: Significant difference at $P < 0.001$ β: refers to the relation of group IV or group V with Group III
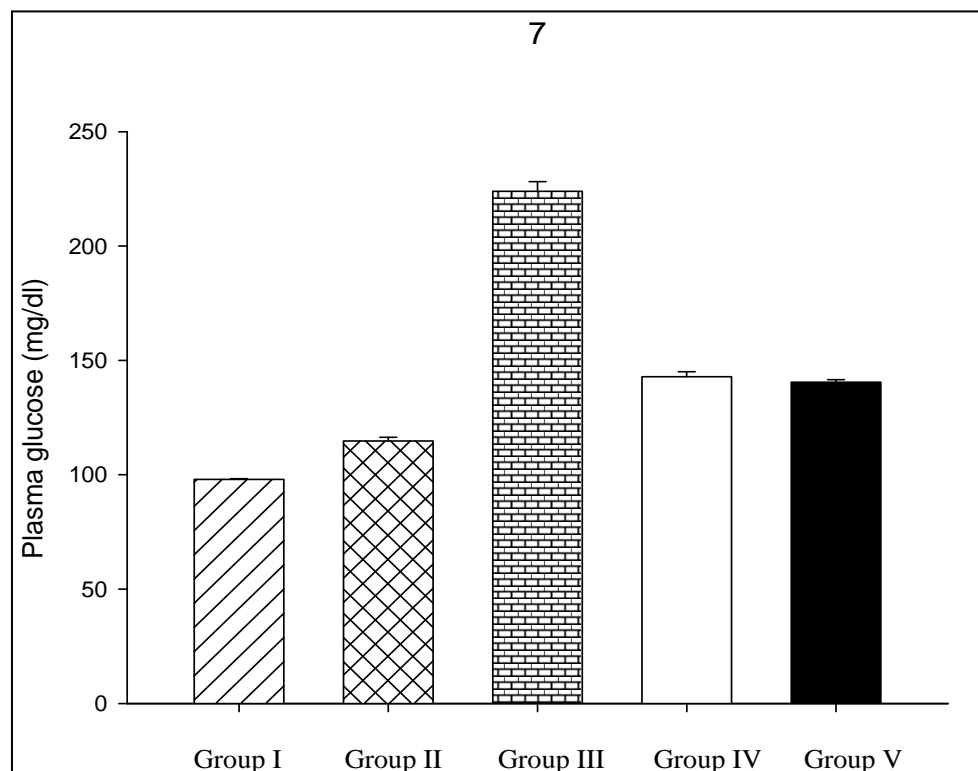
Figure (7): Plasma glucose concentration of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

with vitamins C and E before or post STZ-diabetic induction were significantly increased (P < 0.001) compared to that of the control rats group. The plasma glucose level of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased (P < 0.001) than that of the rats group supplemented with vitamin C and E. The rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant decreases (P < 0.001) of plasma glucose level compared to that of the STZ-diabetic rats group (Table 6 & Fig. 7).

> ➢ **Lipid profile:**

Plasma total lipids showed significant increases (P < 0.001) in STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction in relation to that of the control rats group. The plasma total lipids of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased (P < 0.001) than that of the rats group supplemented with vitamin C and E. The rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly decreased (P < 0.001) in plasma total lipids than that of the STZ-diabetic rats group (Table 7 & Fig. 8-1).

Plasma triglyceride levels showed significant increases (P < 0.001) in STZ-diabetic rats group and rats groups supplemented with vitamins C and E before or post STZ-diabetic induction in relation to that of the control rats group. The plasma triglyceride levels of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased (P <

Table (7): Plasma lipid profile of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / *Parameters*	Group I	Group II	Group III	Group IV	Group V	P
Total lipids (mg/dl)	1.04 ± 0.01	1.03 ± 0.01	1.18 ± 0.01$^{@***\alpha***}$	1.12 ± 0.02$^{@***\alpha***\beta***}$	1.14 ± 0.04$^{@***\alpha***\beta***}$	***
Triglycerides (mg/dl)	82.59 ± 1.03	82.79 ± 1.31	212.43 ± 1.60$^{@***\alpha***}$	112.19 ± 1.25$^{@***\alpha***\beta***}$	115.93 ± 0.68$^{@***\alpha***\beta***\delta**}$	***
Cholesterol (mg/dl)	103.45 ± 1.81	82.75 ± 0.86$^{@***}$	128.99 ± 0.86$^{@***\alpha***}$	108.99 ± 1.18$^{@**\alpha***\beta***}$	121.33 ± 0.67$^{@***\alpha***\beta***\delta***}$	***
LDL-cholesterol (mg/dl)	24.69 ± 0.41	19.96 ± 0.33$^{@***}$	52.43 ± 0.45$^{@***\alpha***}$	37.68 ± 0.98$^{@***\alpha***\beta***}$	51.55 ± 1.62$^{@***\alpha***\delta***}$	***
HDL-cholesterol (mg/dl)	63.50 ± 0.89	56.03 ± 0.31$^{@***}$	36.58 ± 0.31$^{@***\alpha***}$	43.52 ± 1.38$^{@***\alpha***\beta***}$	40.65 ± 1.29$^{@***\alpha***\beta**\delta*}$	***

All data expressed as mean ± SD

*: Significant difference at $P < 0.05$ @: refers to the relation of the groups with group I

**: Significant difference at $P < 0.01$ α: refers to the relation of the group III or group IV or group V with group II

***: Significant difference at $P < 0.001$ β refers to the relation of group IV or group V with Group III

δ: refers to the relation of group V and group IV

0.001) than that of the rats group supplemented with vitamin C and E. Plasma triglyceride levels of the rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly decreased (P < 0.001) than that of the STZ-diabetic rats group. Rats group supplemented with vitamins C and E post STZ-diabetic induction were a significantly increased (P < 0.01) in triglyceride level than those of rats group supplemented with vitamins C and E before STZ-diabetic induction (Table 7 & Fig. 8-2).
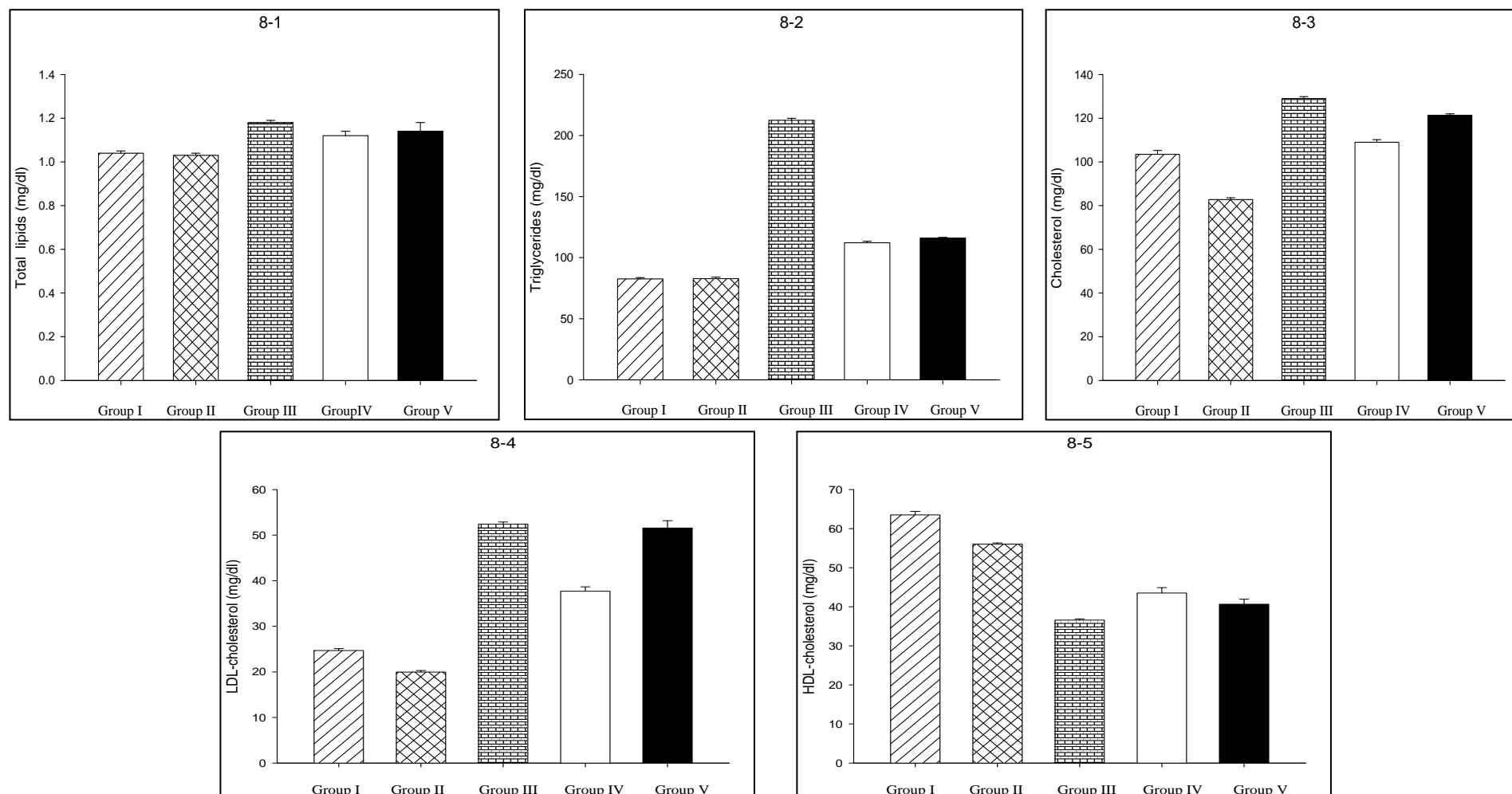
Rats group supplemented with vitamins C and E showed a significant decrease (p < 0.001) in plasma total cholesterol than that of control rats group. Plasma total cholesterol levels were recorded to be significantly higher (P < 0.001, P < 0.01 & P < 0.001) in STZ-diabetic rats group, rats groups supplemented with vitamins C and E before or post STZ-diabetic induction respectively than that of the control rats group. The plasma total cholesterol levels of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased (P < 0.001) than that of the rats group supplemented with vitamin C and E. Plasma total cholesterol levels of the rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly decreased (P < 0.001) than that of the STZ-diabetic rats group. Rats group supplemented with vitamins C and E post STZ-diabetic induction were a significantly increased (P < 0.001) in total cholesterol level than those of rats group supplemented with vitamins C and E before STZ-diabetic (Table 7 & Fig. 8-3).

Plasma LDL-cholesterol level of rats group supplemented with vitamins C and E was lower (P < 0.001) than that of the control rats

group. Plasma LDL-cholesterol levels were significantly higher (P < 0.001) in STZ-diabetic rats group and rats groups supplemented with vitamins C and E before or post STZ-diabetic induction in relation to that of the control rats group. Plasma LDL-cholesterol levels of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased (P < 0.001) than that of the rats group supplemented with vitamin C and E. Plasma LDL-cholesterol levels of the rats group supplemented with vitamins C and E before STZ-diabetic induction was significantly decreased (P < 0.001) than that of the STZ-diabetic rats group. Rats group supplemented with vitamins C and E post STZ-diabetic induction (group V) had a significantly higher (P < 0.001) plasma LDL-cholesterol level than that of the rats group supplemented with vitamins C and E before STZ-diabetic induction (group IV)(Table 7 & Fig. 8-4).

Plasma HDL-cholesterol levels were significantly lower (P < 0.001) in rats group supplemented with vitamins C and E (group II), STZ-diabetic rats group (group III) and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction (groups IV and V) in comparison with that of the control rats group (group I). Plasma HDL-cholesterol levels of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly decreased (P < 0.001) than that of the rats group supplemented with vitamin C and E. Plasma HDL-cholesterol levels of the rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased (P < 0.001) than that of the STZ-diabetic rats group. Plasma HDL-cholesterol level of rats group supplemented with vitamins C and E post STZ-diabetic

Figure (8): Plasma lipid profile [total lipids (8-1), triglyceride (8-2), cholesterol (8-3), LDL-cholesterol (8-4) and HDL-cholesterol (8-5)] of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

induction (group V) was significantly lower than that of the rats group supplemented with vitamins C and E before STZ-diabetic induction (group IV) (Table 7 & Fig. 8-5).

➢ Total protein:

Plasma total protein of rats group supplemented with vitamins C and E (group II), STZ diabetic rats group (group III) and rats groups supplemented with vitamins C and E before or post STZ-diabetic induction (groups IV and V) were significantly lower   ($P < 0.001$) than that of the control rats group (group I). Plasma total protein of the STZ-diabetic rats group and rats group supplemented with vitamins C and E post STZ-diabetic induction were significantly decreased ($P < 0.001$) than that of the rats group supplemented with vitamin C and E. Plasma total protein of rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly increased ($P < 0.001$ & $p < 0.05$, respectively) than that of the STZ-diabetic rats group. Plasma total protein of rats group supplemented with vitamins C and E post STZ-diabetic induction was significantly lower ($P < 0.05$) than that of the rats group supplemented with vitamins C and E before STZ-diabetic induction (Table 8 & Fig. 9-1).

Plasma albumin contents of all treated groups were significantly decreased ($P < 0.001$) than that of the control rats group. Plasma albumin contents of the STZ-diabetic rats group and rats group supplemented with vitamins C and E before STZ-diabetic induction were significantly decreased ($P < 0.001$) than that of the rats group supplemented with vitamin C and E. Plasma albumin contents of rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly higher ($P < 0.01$) than that of the STZ-

Table (8): Plasma proteins concentration of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups Parameters	Group I	Group II	Group III	Group IV	Group V	P
Total protein (g/dl)	8.04 ± 0.22	7.13 ± 0.62$^{@***}$	6.40 ± 0.57$^{@***\alpha***}$	7.05 ± 0.62$^{@***\beta***}$	6.64 ± 0.22$^{@***\alpha***\beta*\delta*}$	***
Albumin (g/dl)	4.31 ± 0.01	3.85 ± 0.01$^{@***}$	3.37 ± 0.02$^{@***\alpha***}$	3.64 ± 0.01$^{@***\alpha***\beta***}$	3.89 ± 0.01$^{@***\beta***\delta**}$	***
Globulin (g/dl)	3.73 ± 0.21	3.38 ± 0.61$^{@***}$	3.03 ± 0.55$^{@***\alpha***}$	3.41 ± 0.61$^{@***\alpha*\beta***}$	2.75 ± 0.21$^{@***\alpha***\beta***\delta***}$	***

All data expressed as mean ± SD

*: Significant difference at $P < 0.05$ @: refers to the relation of the groups with group I

**: Significant difference at $P < 0.01$ α: refers to the relation of the group III or group IV or group V with group II
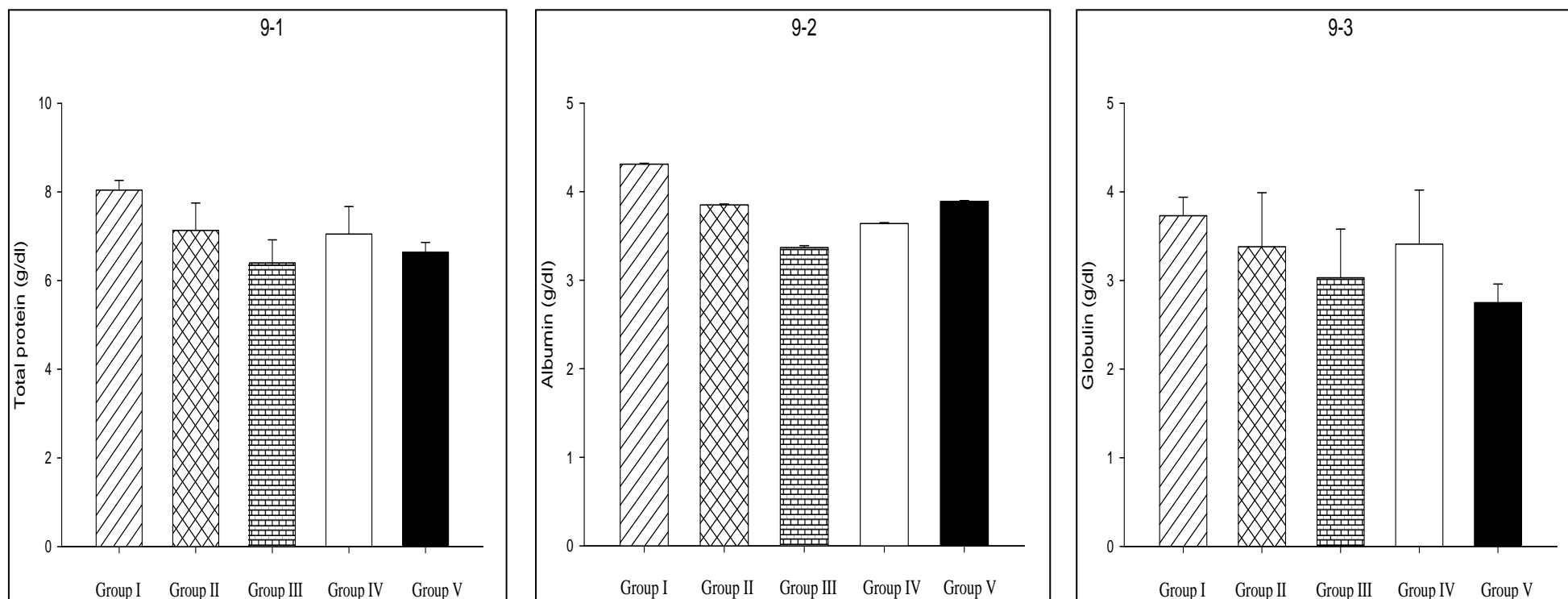
***: Significant difference at $P < 0.001$ β: refers to the relation of group IV or group V with Group III

δ: refers to the relation of group V and group IV

Figure (9): Plasma proteins concentration [total protein (9-1), Albumin (9-2) and Globulin (9-3)] of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

diabetic rats group. Plasma total albumin contents of rats group supplemented with vitamins C and E post STZ-diabetic induction was significantly increased (P < 0.01) than that of the rats group supplemented with vitamins C and E before STZ-diabetic induction (Table 8 & Fig. 9-2).

Plasma globulin contents of all treated rats groups were significantly decreased (P < 0.001) than that of the control rats group. Plasma globulin contents of the STZ-diabetic rats group and rats group supplemented with vitamins C and E post STZ-diabetic induction were significantly decreased (P < 0.001) than that of the rats group supplemented with vitamin C and E. Rats group supplemented with vitamins C and E before STZ-diabetic induction was significantly increased than that of the rats group supplemented with vitamins C and E. Rats group supplemented with vitamins C and E before STZ-diabetic induction was significantly increased (P < 0.001) in plasma globulin content compared to that of the STZ-diabetic rats group. Rats group supplemented with vitamins C and E post STZ-diabetic induction had a significantly lower (P < 0.001) plasma globulin content than that of the STZ-diabetic rats group. Rats group supplemented with vitamins C and E post STZ-diabetic induction had a significantly lower (P < 0.001) plasma globulin content than that of the rats group supplemented with vitamins C and E before STZ-diabetic induction (Table 8 & Fig. 9-3).

➢ **Plasma urea:**

Plasma urea nitrogen was significantly higher (P < 0.001, P < 0.01 & P < 0.01)in STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction, respectively in relation to that of the control rats group. Plasma urea nitrogen were

Table (9): Plasma urea nitrogen, uric acid and creatinine concentrations of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / *Parameters*	Group I	Group II	Group III	Group IV	Group V	P
Urea nitrogen (mg/dl)	4.75 ± 0.04	4.74 ± 0.04	5.51 ± $0.08^{@***\alpha***}$	4.90 ± $0.01^{@**\alpha**\beta***}$	4.92 ± $0.02^{@**\alpha**\beta***}$	***
Uric acid (mg/dl)	2.86 ± 0.01	2.88 ± 0.03	2.31 ± $0.01^{@***\alpha***}$	2.50 ± $0.02^{@***\alpha***\beta***}$	2.52 ± $0.01^{@***\alpha***\beta***}$	***
Creatinine (mg/dl)	0.44 ± 0.03	0.44 ± 0.04	0.75 ± $0.05^{@***\alpha***}$	0.61 ± $0.05^{@**\alpha**\beta*}$	0.62 ± $0.05^{@***\alpha***\beta*}$	***

All data expressed as mean ± SD
*: Significant difference at P < 0.05
**: Significant difference at P < 0.01
***: Significant difference at P < 0.001

@: refers to the relation of the groups with group I
α: refers to the relation of the group III or group IV or group V with group II
β: refers to the relation of group IV or group V with Group III

significantly higher (P < 0.001, p < 0.01, p < 0.01) in the STZ-diabetic rats group (group III) and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction (group IV and group V) respectively than that of the rats group supplemented with vitamins C and E. Plasma urea nitrogen were significantly lower (P < 0.001) in rat groups supplemented with vitamins C and E before or post STZ-diabetic induction compared to that of the STZ-diabetic rats group (Table 9 & Fig. 10-1).
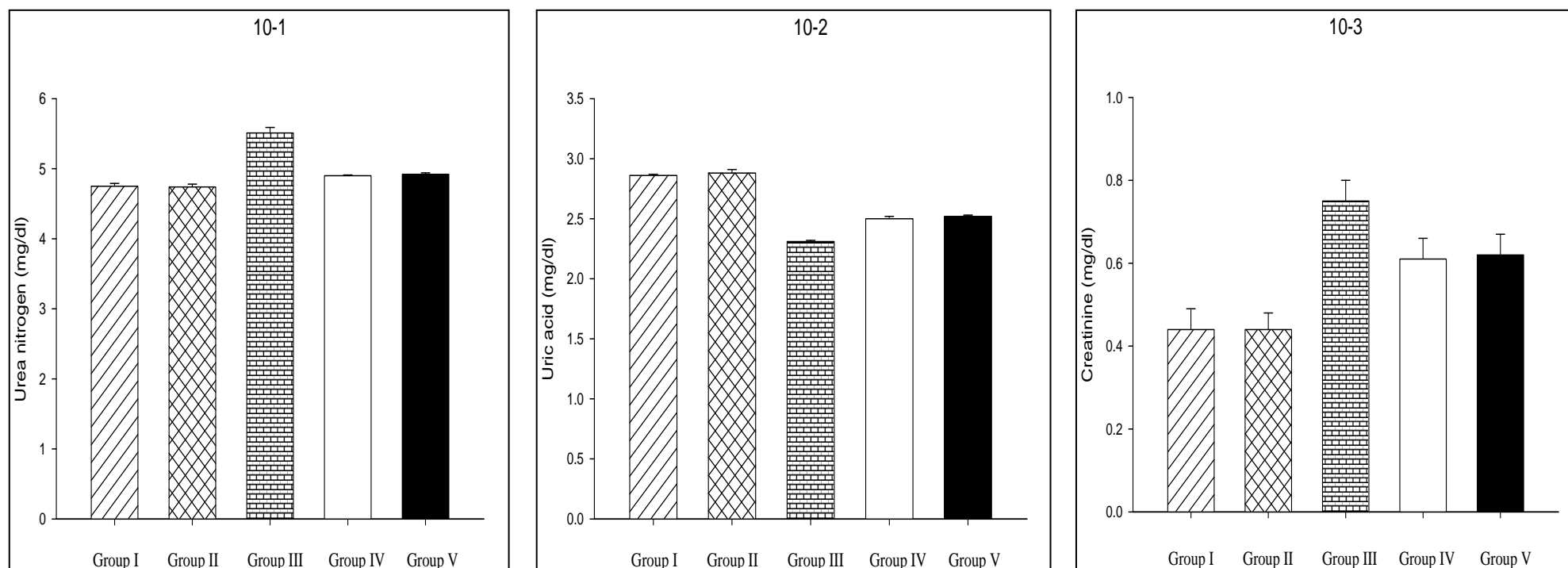
➢ **Plasma uric acid:**

Plasma uric acid was recorded to be significantly lower (P < 0.001) in STZ-diabetic rats group and rat groups supplemented with vitamins C and E before and post STZ-diabetic induction compared to that of the control rats group. Plasma uric acid was significantly lower (P < 0.001) in the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction than that of the rats group supplemented with vitamins C and E. Uric acid in plasma were recorded to be significantly higher (P < 0.001) in rat groups supplemented with vitamins C and E before or post STZ-diabetic induction than that of the STZ-diabetic rats group (Table 9 & Fig. 10-2).

➢ **Plasma creatinine:**

Plasma creatinine concentrations were recorded to be significantly increased (P < 0.001, P < 0.01 & P < 0.001) in STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction, respectively compared to that of the control rats group. Plasma creatinine concentrations of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction were significantly higher (P < 0.001, P < 0.01 & P <

Figure (10): Plasma urea nitrogen (10-1), uric acid (10-2) and creatinine (10-3) concentrations of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

0.001, respectively) than that of the rats group supplemented with vitamins C and E. Plasma creatinine concentrations were found to be significantly lower (P < 0.01) in rats group supplemented with vitamins C and E before or post STZ-diabetic induction than that of the STZ-diabetic rats group (Table 9 & Fig. 10-3).

- **Plasma transaminases:**

Plasma transaminases (ALT and AST) activities showed significant increase (P < 0.001) in STZ-diabetic rats group and rat groups supplemented with vitamin C and E before or post STZ-diabetic induction compared to that of the control rats group. ALT and AST activities showed significant increase (P < 0.001) in STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction compared to that of the rats group supplemented with vitamins C and E. ALT and AST activities showed significant decrease (P < 0.001) in rats group supplemented with vitamins C and E before or post STZ-diabetic induction compared to that of the STZ-diabetic rats group (Table 10 and Fig.11-1 & fig.11-2).

- **Plasma insulin:**

Plasma insulin levels of the STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant decrease (P < 0.001) compared to that of the control rats group. The STZ-diabetic rats group and rat groups supplemented with vitamins C and E before or post STZ-diabetic induction showed significant decrease (P < 0.001) in plasma insulin levels compared to that of the rats group supplemented with vitamins C and E. Plasma insulin levels of rats group supplemented with vitamins C

Table (10): Transaminases activity (alanine aminotransaminase, ALT and aspartate aminotransaminase, AST) of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / Parameters	Group I	Group II	Group III	Group IV	Group V	P
ALT (IU/L)	27.67 ± 1.17	27.52 ± 1.12	49.58 ± 2.87$^{@***\alpha***}$	41.11 ± 2.52$^{@***\alpha***\beta***}$	40.58 ± 3.71$^{@***\alpha***\beta***}$	***
AST (IU/L)	44.67 ± 1.17	44.36 ± 1.02	67.83 ± 3.20$^{@***\alpha***}$	61.17 ± 2.20$^{@***\alpha***\beta***}$	59.69 ± 2.15$^{@***\alpha***\beta***}$	***

All data expressed as mean ± SD

*: Significant difference at P < 0.05   @: refers to the relation of the groups with group I

**: Significant difference at P < 0.01   α: refers to the relation of the group III or group IV or group V with group II

***: Significant difference at P < 0.001   β refers to the relation of group IV or group V with Group III
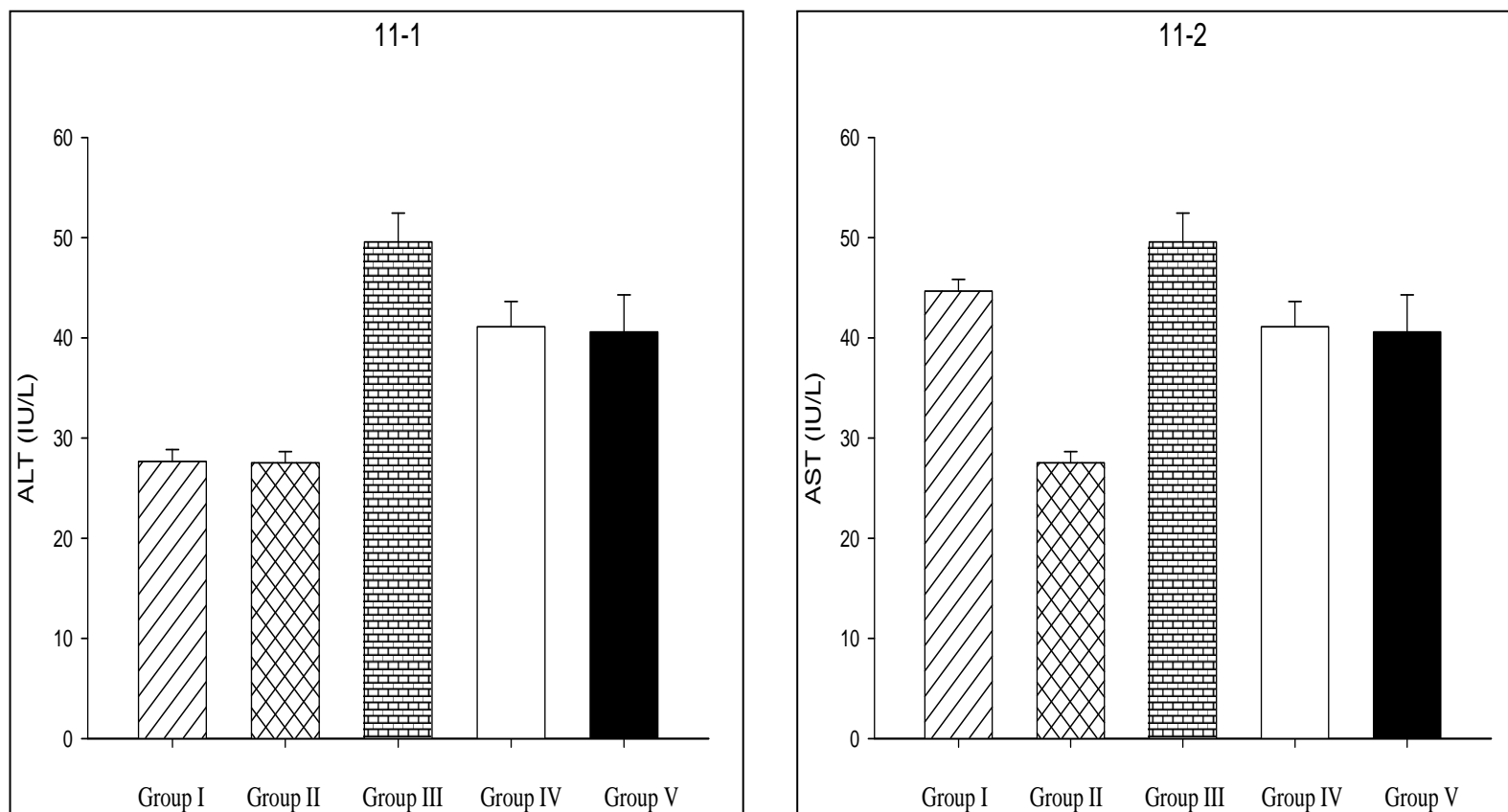
Figure (11): Transaminases activity [alanine aminotransaminase; ALT (11-1) and aspartate aminotransaminase, AST (11-2)] of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Table (11): Insulin levels of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

Rat groups / Parameters	Group I	Group II	Group III	Group IV	Group V	P
Insulin (MIU/ml)	13.86 ± 1.11	13.42 ± 1.01	6.29 ± 0.31$^{@***\alpha***}$	7.89 ± 0.67$^{@***\alpha***\beta**}$	8.06 ± 0.59$^{@***\alpha***\beta**}$	***

All data expressed as mean ± SD
*: Significant difference at $P < 0.05$ @: refers to the relation of the groups with group I
**: Significant difference at $P < 0.01$ α refers to the relation of the group III or group IV or group V with group II
***: Significant difference at $P < 0.001$ β: refers to the relation of group IV or group V with Group III
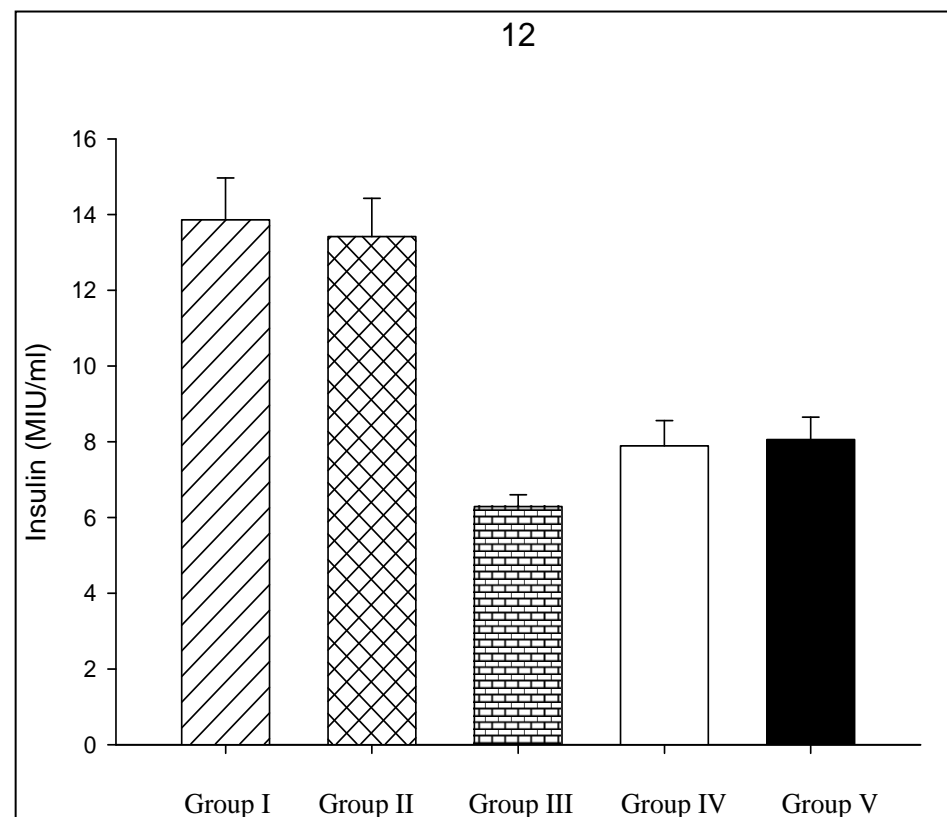
Figure (12): Insulin levels of control rats group (Group I), rats group supplemented with vitamins C and E (Group II), STZ-diabetic rats group (Group III), rats group supplemented with vitamins C and E before STZ-diabetic induction (Group IV) and rats group supplemented with vitamins C and E post STZ-diabetic induction (Group V).

and E before or post STZ-diabetic induction were significantly higher (P < 0.01) than that of the STZ-diabetic rats group (Table 11 & Fig. 12).