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Running title: Effects of Vitamin C and *Cannabis sativa* on oxidative stress in Wistar Rats

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ABSTRACT

Consumption and legalization of *Cannabis sativa* (CS) are increasing at a rapid rate due to its medicinal and recreational importance. However, several studies have revealed that CS stimulates oxidative stress (OS) which could affect the antioxidant defense system of the body. This research examined and compared the protective role of vitamin C (Vit C) on *Cannabis sativa* (CS)-induced oxidative stress in male (M) and female (F)Wistar rats. Post-acclimation (14 days), M and F animals were separately allocated to four groups. Males (1M, 2M, 3M, and 4M) and females (1F, 2F, 3F, and 4F) groups were administered orally, 1.0 mL of distilled water (control), CS (4.0 mg/kg), Vit C (4.0 mg/kg) and CS (4.0 mg/kg) + Vit C (4.0 mg/kg) respectively, for 21 days. Glutathione peroxide (GPx), Superoxide dismutase (SOD), Catalase, Glutathione reductase (GSH), Total antioxidant capacity (TAC), lactate dehydrogenase (LDH), and Malondialdehyde (MDA) were quantified following standard protocols. The study showed no significant differences in measured parameters between the groups treated with Vit C (4mg/kg) as comparable to the controls in both M and F rats. However, the groups treated with CS (4 mg/kg) exhibited significant ($p<0.05$) reduction in GPx, SOD, Catalase, GSH, and TAC while elevating LDH and MDA, compared to control and other treated groups in both M and F rats. In contrast, the groups treated with CS (4mg/kg)+Vit C (4mg/kg) significantly ($p<0.05$) increase GPx, SOD, catalase, GSH, and TAC with significant ($p<0.05$) decrease in LDH and MDA, compared to CS (4 mg/kg), and no significant differences in the controls and Vit C (4mg/kg) treated groups in both M and F rats. In conclusion, Vit C appeared to attenuate CS-associated oxidative stress. The observed effects were more pronounced in males compared to females, indicating a sex-dependent response. The results suggest that Vit C may be used as supplement to prevent oxidative stress which could be induced by CS. Further study is needed to show if similar effects could be observed in human subjects.

Keywords: *Cannabis sativa*; Oxidative stress; Vitamin C; Sex dependent; Wistar rats

INTRODUCTION

Cannabis sativa (CS) has been utilized for medicinal purposes since ancient times due to its abundant phytochemical content [1], hence the quest for preventing its oxidative effects in the body. This substance is widely used as an illicit drug globally [2]. Cells' normal redox state can be disrupted, leading to the production of peroxides and free radicals, damaging all cell components, including proteins, lipids, and DNA [3]. CS, botanically referred to as *Cannabis sativa* (CS), is a multipurpose flowering plant that has been cultivated for centuries for a variety of applications [4]. It has attracted considerable interest due to its complex chemical profile, which comprises more than 100 biologically active compounds known as cannabinoids, in addition to terpenes, flavonoids, and other phytochemicals [5]. Tetrahydrocannabinol (THC) is the main psychoactive constituent responsible for the characteristic euphoric effects commonly associated with cannabis consumption [6]. It is cultivated for multiple purposes, including medicinal, recreational, industrial, and spiritual uses. In clinical settings, it has gained recognition for its potential in managing symptoms related to various medical conditions such as chronic pain, nausea, epilepsy, and certain mental health disorders [7]. Consequently, medical cannabis has been legalized in several regions, permitting its prescription or recommendation by healthcare practitioners for approved indications [8]. Recreational use of cannabis is also widespread globally, primarily due to its psychoactive effects [9]. Several studies have revealed the adverse effects of CS consumption/smoking in the body [10-21]. Oxidative stress (OS) is caused by an imbalance between pro-oxidants and antioxidants [22]. The ratio can be influenced by elevated levels of reactive oxygen species (ROS) or a decrease in antioxidant defense mechanisms [23]. OS can also arise from an imbalance in the body's oxidizing system, primarily composed of free radicals, reactive oxygen species (ROS), and reactive nitrogen species (RNS) [24]. Antioxidant systems are essential in neutralizing free radicals that can have numerous harmful effects [25]. However, experimental and clinical studies have demonstrated that *Cannabis sativa* may induce oxidative stress in both humans and animal models [26-28].

Vitamin C (ascorbic acid) is widely recognized for its strong antioxidant capacity [29]. In addition, vitamin C supports the regeneration of other antioxidants, including vitamin E, thereby strengthening the body’s defense against oxidative stress [29]. In plants, including cannabis, vitamin C functions as an effective antioxidant by counteracting reactive oxygen species (ROS) and safeguarding cellular components from oxidative injury [30]. Within our research limit, we have not come across any study which has examined and compared the

protective role of Vit C on *Cannabis sativa* (CS)-induced oxidative stress in male (M) and female (F) Wistar rats. This research work therefore aimed to bridge this lacuna so as to identify the potential sex differences and examine oxidative biomarkers (Glutathione peroxide (GPx), superoxide dismutase (SOD), catalase, glutathione reductase (GSH), total antioxidant capacity (TAC), lactate dehydrogenase (LDH), and malondialdehyde (MDA)), to assess the influence of Vit C on CS-induced OS, considering its gender-dependent modulation. The oxidative stress parameters were considered because they provide valuable information about the anti-oxidative defense system of the body. The objective of this study was to investigate the effects of co-administration of Vit C and CS on oxidative stress in male and female Wistar rats as subjects by considering gender-dependent modulation. The hypotheses of our research work were Vit C would not attenuate CS-induced oxidative stress in male and female Wistar rats (null); and Vit C would attenuate CS-induced oxidative stress in male and female Wistar rats (alternative).

METHODOLOGY

Sample collection:

Cannabis sativa (CS) leaves were donated by National Drug Law Enforcement Agency (NDLEA), Nigeria, for research purpose only.

Extraction of Cannabis sativa leaves [27]:

Extraction of *Cannabis sativa* (CS) was done with Soxhlet apparatus by soaking 400 grams of CS in 98% ethanol for 48 hours. It was filtered and the filtrate was poured into a round-boom conical flask it was fixed with a rotary evaporator. The filtrate was then evaporated and cooled. The dried yield of the extract was 45g (weight of the extract obtained after drying).

Experimental animals:

Twenty male rats with mean weight of 180g ± 1.89g and twenty female rats with mean weight of 165g ± 1.23g used in the present study were obtained from Temilade Animal Venture, Ogbomoso, Oyo State, Nigeria. The animals were housed at room temperature with unrestricted access to diet and water and maintained on a daily light/dark cycle. Principles of laboratory animal care (NIH publication No. 85-23, revised 1985) were followed. The experimental protocol was approved by Ethical Committee of the University of Ilesa, Ilesa, Osun State, Nigeria with approval number (UNILESA-2025/EARC/012).

Experimental protocol:

After 2 weeks of acclimatisation, the animals (male (M) and female (F)) were separately and randomly assigned into four groups of five animals each for male and female. Males (1M, 2M, 3M, and 4M) and females (1F, 2F, 3F, and 4F) groups were administered orally, 1.0 mL of distilled water (control), CS (4.0 mg/kg), Vit C

(4.0 mg/kg) and CS (4.0 mg/kg)+Vit C (4.0 mg/kg) respectively, once daily via oral gavage between 8:00 am to 10:00 am for twenty-one (21) days. The animals had access to food and water ad-libitum. The animals were sacrificed after day 21.

Preparation of serum:

The male and female rats were sacrificed under ketamine anesthesia and blood was collected by cardiac puncture into sterile sample bottles. The blood was left for 30 min to clot and thereafter centrifuged at 625×*g* for 10 min using a Uniscope Laboratory Centrifuge (Model SM800B, Surgifield Medicals, Essex, England). The serum was collected into plain bottles with the aid of a Pasteur pipette. Sera were stored in a freezer maintained at -5 °C and used within 12 hours of preparation.

Drug and assay kits:

The liquid form of Vit C was purchased from One Step Pharmaceutical Company, Ilorin, Kwara State, Nigeria. Lactate dehydrogenase (LDH) activity was assayed spectrophotometrically (Spectramax Plus; Molecular Devices, Sunnyvale, CA, USA) following the kit manufacturer's procedures (product code BXC0243; Fortress Diagnostics, UK). The determination of serum superoxide dismutase (SOD) concentration was done with SOD colorimetric assay kit (Fortress Diagnostics Ltd., Antrim, UK; Product code: BXC0531), following the manufacturer's protocols. The determination of serum glutathione peroxidase (GPx) activity was done with GPx colorimetric assay kit (BioVision Inc., Milpitas, CA, USA), following the manufacturers protocols. Based on the manufacturer's protocol, total antioxidant capacity (TAC) measurement in the serum was done with a spectrophotometric microplate reader (Spectramax Plus, Molecular Devices, Sunnyvale, CA, USA) using OxiSelect TAC assay kit that uses the single electron transfer mechanism (Cell Biolabs, Inc. San Diego, CA. cat no: STA-360). The continuous catalase activity was determined through spectrophotometric reading [31]. Reduced glutathione (GSH) was measured according to the method of [32]. The assay method of [33], modified by [34] was adopted for Malondialdehyde (MDA).

Statistical analysis:

Results were expressed as the mean ± standard error of mean (S.E.M). Data was analyzed using a two-way Analysis of Variance, followed by the LSD post-hoc test to determine significant differences in all the parameters with the aid of graph pad, version 9.0. Differences with values of $P<0.05$ were considered statistically significant.

RESULTS

The results obtained are presented in Table 1. There was no significant ($p>0.05$) difference in measured parameters between the groups treated with Vit C (4mg/kg) as compared to the

controls in both M and F rats. However, the groups treated with CS (4 mg/kg) exhibited significant ($p<0.05$) reduction in GPx, SOD, Catalase, GSH, and TAC while elevating LDH and MDA, compared to the controls and Vit C (4mg/kg) treated groups in both M and F rats. In contrast, the groups treated with CS (4mg/kg)+Vit C (4mg/kg) significantly ($p<0.05$) increase GPx, SOD, Catalase, GSH, and TAC, with significant ($p<0.05$) decrease in LDH and MDA, compared to CS (4 mg/kg), and with no significant differences in the controls and Vit C (4mg/kg) treated groups in both M and F rats.

Table 1: Showing oxidative stress markers of rats (male (M) and female (F)) for control and treated (4.0 mg/kg bw CS, 4.0 mg/kg bw Vit C, and 4.0 mg/kg bw CS +4.0 mg/kg bw Vit C) groups.

Treated groups	GPx (mmol/l)	SOD (U/L)	Catalase, (u/l)	GSH (u/l)	TAC (umol/l)	LDH (u/l)	MDA (umol/l)
Control (M)	8.10 ±0.78	158.63±6.43	47.72±0.23	132.12±4.56	95.21±1.72	754.23±20.14	28.56±0.50
Control (F)	3.07 ±0.26	120.50±6.98	28.05±0.51	110.08±4.70	87.40±1.50	626.13±23.38	23.40±0.52
4mg/kg CS (M)	4.45 ±0.65*	92.34±3.65*	34.32±1.02*	100.67±4.01*	80.56±1.52*	895.23±12.98*	35.23±9.65*
4mg/kg CS (F)	2.28±0.09*	74.34±7.01*	24.94±0.42*	94.28±1.12*	73.39±2.11*	694.76±23.01*	26.00±0.32*
4mg/kg Vit C (M)	8.10 ±0.78	158.63±6.43	47.72±0.23	132.12±4.56	95.21±1.72	754.23±20.14	28.56±0.50
4mg/kg Vit C (F)	3.07 ±0.26	120.50±6.98	28.05±0.51	110.08±4.70	87.40±1.50	626.13±23.38	23.40±0.52
4mg/kg CS + 4mg/kg Vit C(M)	7.10 ±0.71#	151.21±5.43#	43.26±0.18#	128.65±3.78#	94.34±1.68#	728.10±23.13#	27.29±0.53#
4mg/kg CS+4mg/kg Vit C (F)	3.02 ±0.26#	118.91±6.05#	27.11±0.46#	106.12±5.10#	80.65±1.21#	622.45±23.21#	20.67±0.83#

Values are expressed as mean ± SEM; *P< 0.05 vs control and other treatment groups (M and F); #P< 0.05 vs CS-treated groups (M and F)

DISCUSSION

Oxidative stress is the result of an imbalance between the systemic expression of reactive oxygen species (ROS) and a biological system's ability to rapidly detoxify the reactive intermediates or repair the harm they cause [35]. Peroxides and free radicals are created when a cell's natural redox state is destabilized. These molecules damage proteins, lipids, DNA, and other components of the cell and can have harmful consequences [36]. Oxidative stress brought on by oxidative metabolism damages DNA strands along with their bases [37]. Reactive oxygen species such superoxide radical (O^{2-}), hydroxyl radical (OH), and hydrogen peroxide (H_2O_2) are the primary causes of indirect base damage [38]. Previous studies have established that vit C acts as an antioxidant [19, 39]. Catalase is a major antioxidant enzyme that facilitates the breakdown of hydrogen peroxide into water and molecular oxygen through a two-step reaction [40]. Similarly, glutathione (GSH) has gained considerable attention as a biomarker of

oxidative stress due to its essential role in xenobiotic detoxification and protection against oxidative damage. The availability of glutathione in its reduced form (GSH) is critical for maintaining cellular health [41]. Reduced GSH levels have been associated with aging and the pathogenesis of several diseases, including AIDS, rheumatoid arthritis, muscular dystrophy, amyotrophic lateral sclerosis, Alzheimer's disease, alcoholic liver disease, cataract formation, respiratory distress syndrome, progeria, and Werner syndrome, as reported in both human and animal studies [42]. Our results revealed that oxidative parameters (catalase, SOD, GSH, glutathione peroxidase (GPx), and total antioxidant capacity (TAC)) were not affected when Vit C alone was administered. However, a reduction in their levels were observed when CS was administered alone, suggesting oxidative damage in both male and female rats. This was in line with the findings of [26, 28] who recorded oxidative damage following CS administration in male and female rats. Lipid peroxidation results in the formation of malondialdehyde (MDA), which is widely used as a biomarker for assessing oxidative stress in various biological samples, including blood, urine, and exhaled breath condensate, particularly in patients with cancer and cardiovascular, pulmonary, and neurological diseases [43]. Elevated level of MDA recorded in this study following CS administration demonstrated tissue damage, which was consistent with the result of [44]. Tissue injury is often accompanied by oxidative stress, elevated LDH levels may serve as an indirect indicator of oxidative damage [45]. Increase in the level of LDH observed after CS administration suggests the occurrence of damage to the tissue in both male and female rats. In contrast, there were no changes in MDA and LDH following the administration of Vit C alone. Our results also showed that administration of Vit C and CS reversed the effects caused by CS alone on oxidative stress, suggesting the anti-oxidative potential of Vit C. This concurred with the findings of [19, 27, 46]. The effects of Vit C on cannabis-induced oxidative stress were more in female than in male rats, indicating a potential sex difference. This could be due to the widely distribution of cannabinoid receptors in male than female [47] which stimulated the activities of CS administered.

CONCLUSION

In conclusion, Vit C appeared to attenuate CS-associated oxidative stress. The observed effects were more pronounced in males compared to females, indicating a sex-dependent response. This study suggests that Vit C may be used as supplement to prevent oxidative stress which could be induced by CS. Further study is needed to show if similar effects could be observed in human subjects.

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REFERENCES

1. Arif M, Saifi MS, Kaish M, Kushwaha SP. Cannabis sativa L.-An Important Medicinal Plant: A Review of its Phytochemistry, Pharmacological Activities and Applications in Sustainable Economy. International Journal of Pharma Professional's Research. Vol. 14(3), 2023: 43-59
2. Chouvy PA. Cannabis cultivation in the world: heritages, trends and challenges. EchoGéo. Vol. 48, 2019.
3. Sadiq IZ. Free radicals and oxidative stress: Signaling mechanisms, redox basis for human diseases, and cell cycle regulation. Current Molecular Medicine. Vol. 23(1), 2023: 13-35
4. Andre CM, Hausman JF, Guerriero G. Cannabis sativa. The plant of the thousand and one molecules. Frontiers in plant science. Vol. 7, Feb 2016: 19.
5. Odieka AE, Obuzor GU, Oyedeji OO, Gondwe M, Hosu YS, Oyedeji AO. The medicinal natural products of Cannabis sativa Linn.: A review. Molecules. Vol. 27(5), Mar 2022: 1689.
6. Malabadi RB, Kolkar KP, Chalannavar RK. Δ9-Tetrahydrocannabinol (THC). The major psychoactive component is of botanical origin. International Journal of Innovation Scientific Research and Review. Vol. 5(3), 2023: 4177-4184.
7. Dhanasekaran M, M Nadar R, McDonald K, Deruiter J, Pathak S, Ramesh S, Vijayarani R, Gopal K, Babu Ramapuram J, Dua K, Moore T. A re-evaluation of past to present-day use of the blissful neuronal nutraceutical "Cannabis". Journal of Food Nutrition and Metabolism. October 2022.
8. Page RL, Allen LA, Kloner RA, Carriker CR, Martel C, Morris AA, Piano MR, Rana JS, Saucedo JF. Medical marijuana, recreational cannabis, and cardiovascular health: a scientific statement from the American Heart Association. Circulation. Vol. 142(10), September 2020: e131-152.
9. Urits I, Charipova K, Gress K, Li N, Berger AA, Cornett EM, Kassem H, Ngo AL, Kaye AD, Viswanath O. Adverse effects of recreational and medical cannabis. Psychopharmacology bulletin. Vol. 51(1), January 2021: 94.
10. Oluwasola A, Lukman J, Comfort AM. Effect of Cannabis sativa on Haematological Parameters in Male and Female Wistar Rats. Asian Pacific Journal of MedicalToxicology. Vol. 13(3), November 2024: 90-94
11. Oluwasola A, Balogun ME, Muzzammill SS, Zainab SO, Adekunle OJ, Mariam EB, Nkemdili VJ, Aishat NH, Comfort AM. Effect of Acute Administration of Ethanol Extract of *Cannabis sativa* Leaf on LiverFunction Biomarkers in Male Wistar Rats'. *NISEB journal*. Vol. 22(1), September/December 2022: 20-26
12. Oluwasola A, Ayoola OE, Garba S, Adepoju MA, Biliaminu SA, Olayaki LA. Melatonin Mitigates Hormonal Toxicity in Cannabis-Treated Female Wistar Rats. The Tropical Journal of Health Sciences. Vol. 30(2), July 2023 5: 14-19.
13. Ayoola OE, Oluwasola A, Garba S**.** *Cannabis sativa* exacerbates inflammatory responses in male and female wistar rats. Pacific Journal of Medical Sciences. Vol. 25(2), December 2025: 50-55.
14. Oluwasola A, Ayoola OE, Odetayo AF, Garba S, Olayaki LA. Ameliorative Effect of Melatonin on Reproductive Hormones in Ethanol Extracts of Cannabis sativa-Treated Female Wistar Rats. NISEB Journal. Vol. 22(2), September/December 2022: 27-32.
15. Oluwasola A,Olayaki LA, Ayinde TO**.** Effects of Melatonin andEthanolic Extract of Cannabis sativa Leaves on Sexual Behaviour Parameters of FemaleWistar Rats.Bioscience Research Journal. Vol. 32(1), Feb 2020: 29-36.
16. Olayaki LA, Oluwasola A. Melatonin Mitigates Ovarian Toxicity in Cannabis-Treated Female Witar Rats. Federation of American Societies for Experimental Biology Journal. Vol. 34(S1), March 2020 19: 1-1.
17. Oluwasola A, Olayaki LA, Ayinde TO. Effects of Melatonin on EstrousCycle Changes Induced by Etanolic Extract of

Cannabis sativa in Female Wistar Rats.Nigeria Society of Experimental Biology Journal. Vol. 19(12), June 2019 13: 55-60
18. Oluwasola A, Ayoola OE, Garba Saa'du, Adepoju MA, Balogun ME, Biliaminu SA, Olayaki LA. The Ameliorative effects of Melatonin on Cannabis-induced Liver toxicity in male and female Wistar rats. *The Tropical Journal of Health Sciences*. Volume .30(3), July 2023:20-26.
19. Oluwasola A, Ayinde TO. Comparative Study on the Antioxidant Potentials of Honey and Some Selected Beverages in Male Wistar Rats. *Al-Hikmah Journal of Education.*Vol.6(2), December 2019:1-7
20. Ayoola OE, Oluwasola A, Garba S**.** *Cannabis sativa* exacerbates inflammatory responses in male and female Wistar rats. Pacific Journal of Medical Sciences. Vol. 25(2), December 2025: 50-55.
21. Oluwasola A. Melatonin mitigates hormonal toxicity in cannabis-treated female Wistar rats: involvement of cannabinoid receptors. J of Cannabis Research. Vol. 8(27) January 2026: 1-7.
22. Demirci-Cekic S, Özkan G, Avan AN, Uzunboy S, Çapanoğlu E, Apak R. Biomarkers of oxidative stress and antioxidant defense. Journal of pharmaceutical and biomedical analysis. Vol. 209, 2023: 114477
23. Sachdev S, Ansari SA, Ansari MI, Fujita M, Hasanuzzaman M. Abiotic stress and reactive oxygen species: Generation, signaling, and defense mechanisms. Antioxidants. Vol. 10(2),2021: 277
24. Aranda-Rivera AK, Cruz-Gregorio A, Arancibia-Hernandez YL, Hernanadez-Cruz EY, Pedreza-Chaverri J. RONS and oxidative stress: An overview of basic concepts. Oxygen. Vol. 2(4), 2022: 437-478
25. Ifeanyi, OE. A review on free radicals and antioxidants. Int. J. Curr. Res. Med. Sci. Vol. 4(2), 2018: 123-133
26. Oluwasola A, Usman, LN. Oxidative stress Markers of Male Wistar Rats following recovery period from exposure to Cannabis sativa. Pacific Journal of Medical Sciences. Vol. 25(2), August 2024: 65-74.
27. Oluwasola A, Kolawole Y., Usman, LN, Olanrewaju OA. Effect of co-administration of Cannabis sativa and Vitamin C on Biomarkers of Oxidative stress in Female Wistar Rats. Pacific Journal of Medical Sciences. Vol. 25(2), August 2024: 57-64.
28. Abdulrahim HA, Alagbonsi IA, Oluwasola A, Omeiza NA, Feyitimi AA, Olayaki LA. *Cannabis sativa* and/or melatonin do not alter brain lipid but alter oxidative mechanisms in female rats. Journal of Cannabis Research, 2021, Vol. 3(38): 1-10
29. Khadim RM, Al-Fartusie FS. Antioxidant vitamins and their effect on immune system. In-Journal of Physics: Conference Series. Vol. 1853(1), March 2021: 012065.
30. Mladenov M, Lubomirov L, Grisk O, Avtanski D, Mitrokhin V, Sazdova I, Keremidarska-Markova M, Danailova Y, Nikolaev G, Konakchieva R, Gagov H. Oxidative stress, reductive stress and antioxidants in vascular pathogenesis and aging. Antioxidants. Volume 12(5), May 2023: 1126.
31. Claiborne A, Martin C, McAlister W, Gast M. Antenatal diagnosis of cystic adenomatoid malformation: effect on patient management. Pediatric radiology. Vol. 15, 1985: 337-339
32. Ellman GL. Tissue sulfhydryl groups. Archives of biochemistry and biophysics. Vol. 82(1), 1959: 70-77
33. Hunter C, Mestel L. The structure and stability of self-gravitating disks. Monthly Notices of the Royal Astronomical Society. Vol. 126(4), 1963: 299-315
34. Gutteridge JM, Wilkins S. Copper-dependent hydroxyl radical damage to ascorbic acid: formation of a thiobarbituric acid-reactive product. FEBS letters. Vol. 137(2), 1982: 327-330
35. Afzal S, Abdul Manap AS, Attiq A, Albokhadaim I, Kandeel M, Alhojaily SM. From imbalance to impairment: the central role of reactive oxygen species in oxidative stress-induced disorders and therapeutic exploration. Frontiers in Pharmacology. Vol. 14, 2023: 1269581
36. Valko M, Jomova K, Rhodes CJ, Kuca K, Musilek K. Redox-and non-redox-metal-induced formation of free radicals and their role in human disease. Archives of toxicology. Vol. 90, 2016: 1-37
37. Gonzalez-Hunt CO, Wadhwa M, Sanders LH. DNA damage by oxidative stress: Measurement strategies for two genomes. Current Opinion in Toxicology. Vol. 7, 2018: 87-94

38. Madkour LH. Function of reactive oxygen species (ROS) inside the living organisms and sources of oxidants. Pharm. Sci. Anal. Res. J. Vol. 2, 2019: 180023
39. Gęgotek A, Skrzydlewska E. Ascorbic acid as antioxidant. Vitamins and Hormones. Vol. 121, January 2023: 247-270.
40. Nandi A, Yan LJ, Jana CK, Das N. Role of catalase in oxidative stress-and age-associated degenerative diseases. Oxidative medicine and cellular longevity. Vol. 2019(1), 2019: 9613090.
41. Sánchez-Rodríguez MA, Mendoza-Núñez VM. Oxidative stress indexes for diagnosis of health or disease in humans. Oxidative medicine and cellular longevity. Vol. 2019(1), 2019: 4128152.
42. Liguori I, Russo G, Curcio F, Bulli G, Aran L, Della-Morte D, Gargiulo G, Testa G, Cacciatore F, Bonaduce D, Abete P. Oxidative stress, aging, and diseases. Clinical interventions in aging. Vol. 26, April 2018: 757-772.
43. Mas-Bargues C, Escriva C, Dromant M, Borras C, Vina J. Lipid peroxidation as measured by chromatographic determination of malondialdehyde. Human plasma reference values in health and disease. Archives of biochemistry and biophysics. Vol. 709, September 2021: 108941.
44. Oluwasola A, Olayaki LA, Ayinde TO. Melatonin Mitigates Oxidative Stress in Ethanolic Extract of Cannabis-Treated Female Wistar Rats. Nigeria Journal of Biochemistry and Molecular Biology. Vol. 35(1), February 2019 8:7-16.
45. Tee JK, Ong CN, Bay BH, Ho HK, Leong DT. Oxidative stress by inorganic nanoparticles. Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology. Vol. 8(3), May 2016: 414-438.
46. Khazaie S, Jafari M, Heydari J, Asgari A, Tahmasebi K, Salehi M, Abedini MS. Modulatory effects of vitamin C on biochemical and oxidative changes induced by acute exposure to diazinon in various rat tissues: prophylactic and therapeutic roles. Journal of animal physiology and animal nutrition. Vol. 103(5), September 2019: 1619-1628.
47. Liu X, Li X, Zhao G, Wang F, Wang L. Sexual dimorphic distribution of cannabinoid 1 receptor mRNA in adult C57BL/6J mice. Journal of Comparative Neurology. Vol. 528(12), August 2020: 1986-99.