European Journal of Medicinal Plants

31(2): 10-17, 2020; Article no.EJMP.54927
ISSN: 2231-0894, NLM ID: 101583475

Evaluation of Antioxidant and Anti-Parkinson Activity of *Portulaca oleracea* Seed Methanolic Extract

Santosh Kumar Vaidya[1*], Dharmesh K. Golwala[1], Darpini S. Patel[2] and Satyajit Sahoo[3]

[1]Shankersinh Vaghela Bapu Institute of Pharmacy, Vasan, Gandhinagar, Gujarat, India.
[2]K. B. Institute of Pharmaceutical Education and Research, Gandhinagar, Gujarat, India.
[3]C. U. Shah College of Pharmacy and Research, Wadhwan, Surendranagar, Gujarat, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors DKG and SS helped to collection, authenticate and phytochemical investigation of plant material. Author DSP helped in statistical data analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJMP/2020/v31i230211
Editor(s):
(1) Dr. Paola Angelini, Department of Chemistry, Biology and Biotechnology, University of Perugia, Italy.
(2) Prof. Marcello Iriti, Professor of Plant Biology and Pathology, Department of Agricultural and Environmental Sciences, Milan State University, Italy.
Reviewers:
(1) Danny Faturachman, Darma Persada University, Indonesia.
(2) Shailja Puri, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/54927

Original Research Article

Received 17 December 2019
Accepted 21 February 2020
Published 22 February 2020

ABSTRACT

Aim: Evaluation of Antioxidant and Anti-Parkinson activity of *Portulaca oleracea* seed methanolic extract.
Place: C. U. Shah College of Pharmacy and Research, Wadhwan, Surendranagar, Gujarat, India.
Methodology: Collect plant materials were extracted with methanol. Extract was subjected to qualitative and quantitative investigation and antioxidant properties of extract was determine by Nitric oxide free radical scavenging activity and Reducing power by $FeCl_3$ method.
Anti-Parkinson activity evaluated by two behavioral models namely, haloperidol induced catalepsy, and orofacial dyskinesia both models various behavioral activity/ parameter (catalepsy, vacuous chewing movement and tongue protrusion) were evaluated.
Results: Preliminary qualitative phytochemical screening was to reveal presence of polyphenols, flavanoids, glycoside, alkaloids, carbohydrates and reducing sugar etc. Based preliminary

**Corresponding author: E-mail: skvaidya1979@gmail.com;*

qualitative phytochemical screening; quantitative estimation of methanolic extract showed significant amount of polyphenols. *In-vitro* antioxidants was performed by two method reducing power by $FeCl_3$ and nitric oxide free radical scavenging, the methanolic extract shows significant antioxidant properties, based on polyphenols and antioxidant properties extracts was used for the Anti-Parkinson activity Haloperidol induced catalepsy in mice Treatment with *Portulaca oleracea* seed showed a significant ($P<0.01$) reduction in the duration of cataleptic behavior dose dependently when compared to haloperidol treated group. Haloperidol induced orofacial dyskinesia in rat recovery of orofacial dyskinesia as evidenced by decrease in the frequency of vacuous chewing movement and tongue significant ($P<0.05$) decrease in the frequency of vacuous chewing & tongue protrusion while *Portulaca oleracea* seed (200 mg/kg) was found to be insignificant in this respect.

Conclusion: After *Portulaca oleracea* seed (MLPO) treatment, the significant alterations produced in Parkinson's affected rodents in respect to lipid peroxidation and antioxidant concentration significantly contributing its antioxidant potential. This antiperoxide action observed in *Portulaca oleracea* seed (MLPO) treated animals might be due to the suppression of the production of reactive oxygen species. This compound may be found to scavenge free radicals, including hydroxyl anions and reduce the level of lipid peroxidation in MLPO animals. Inhibition of oxidative stress may be one of the possible mechanisms for the anti-Parkinson effects of *Portulaca oleracea* seed (MLPO).

Keywords: Portulaca oleracea seed; alkaloids; antioxidant; Orofacial dyskinesia; vacuous chewing movements and methanolic extract.

1. INTRODUCTION

Parkinson's disease (PD) is the second most common neurodegenerative disorder worldwide which is characterized by the progressive loss of dopaminergic neurons in substantia nigra (SN) [1]. The clinical symptoms of PD include rest tremors, rigidity, bradykinesia and postural imbalance [2]. The aging process of body supports the role in PD, of an impaired function of the mitochondria and degeneration of dopaminergic neuron [3]. The exact reason for Parkinson's disease still unknown, but there is an aging process generation of free radical evidence that nigral neurons might be damaged. Free radicals are thought to be produced locally within the basal ganglia and to lead to progressive damage to and death of substantia nigra neurons [4].

Portulaca oleracea (Linn.) family Portulacaceae commonly called as brihalloni, gholika, lona, lonamla, loni, lonika, lunia, Pigweed, little hogweed or pusley [5]. It is an annual succulent in the family Portulacaceae, which can reach 40 cm in height. It is a native of India and the Middle East, but is naturalized elsewhere and in some regions is considered an invasive weed [6]. It has smooth, reddish, mostly prostrate stems and alternate leaves clustered at stem joints and ends. The yellow flowers have five regular parts and are up to 6 mm wide [5]. The flowers first appear in late spring and continue into mid fall. The flowers open singly at the center of the leaf cluster for only a few hours on sunny mornings. Seeds are formed in a tiny pod, which opens when the seeds are ready. Purslane has a taproot with fibrous secondary roots and is able to tolerate poor, compacted soils and drought [7].

Portulaca oleracea contains minerals, proteins, carbohydrates, β-carotene, vitamins and fatty acids [8,9]. Among the bioactive components and biological activities assigned to the *Portulaca oleracea*, the presence of catecholamine [10] and its antioxidant and anti-inflammatory actions [11,12] deserve to be highlighted. Neuropharmacological actions of the *Portulaca oleracea* extracts were previously reported in rodent models, effects included the reduction of the locomotor activity, the increase in the onset time of pentylenetetrazole-induced convulsions in mice, the opioid mediated anti-nociceptive and muscle relaxant activities in rats [13]. Biological activities also include anti-inflammatory actions. [14,15].

2. MATERIALS AND METHODS

2.1 Extraction

Air dried & coarsely powdered of *Portulaca oleracea* seed was carried out for soxhlet extraction using methanol. The extract was concentrated to dryness under reduced pressure and it was preserved in a refrigerator [16,17].

2.2 Phytochemical Investigation

2.2.1 Preliminary phytochemical investigation

The methanolic extracts of *Portulaca oleracea* seed (MLPO) was subjected to various phytochemical tests for identification of secondary metabolites present in them [18].

2.2.2 Determination of total polyphenols

The total polyphenol content (TPC) was determined by spectrophotometry method, using tannic acid as standard, according to the method described by the International Organization for Standardization (ISO) 14502-1. Briefly, 1.0 ml of the diluted sample extract was transferred in duplicate to separate tubes containing 5.0 ml of a 1/10 dilution of Folin-Ciocalteu's reagent in water [5]. Then, 4.0 ml of a sodium carbonate solution (7.5% w/v) was added. The tubes were then allowed to stand at room temperature for 60 min before absorbance at 765 nm was measured against water. The concentration of polyphenols in samples was derived from a standard curve of tannic acid ranging from 10 to 50 µg/ml and expressed in terms percentage [19].

2.3 Antioxidant Activity

2.3.1 Reducing power by $FeCl_3$

Various concentrations of the extracts in 1.0 ml of deionized water were mixed with phosphate buffer (2.5 ml) and potassium ferricyanide (2.5 ml) and incubated at 50ºC for 20 min. Aliquots of trichloroacetic acid (2.5 ml) were added to the mixture, which was then centrifuged at 3000 rpm for 10 min whenever necessary. The upper layer of solution (2.5 ml) was mixed with distilled water (2.5 ml) and a freshly prepared ferric chloride solution (0.5 ml). The absorbance was measured at 700 nm. A blank was prepared without adding extract. Ascorbic acid at various concentrations was used as standard. Increased absorbance of the reaction mixture indicates increase in reducing power [20].

2.3.2 Nitric oxide free radical scavenging activity

Various concentrations of the extracts in 1.0 ml of methanol were mixed with Sodium nitro prusside (10 mM) in phosphate buffer phosphate buffer and made upto 200 µl with methanol mixture of solution Incubate at room temperature for 150 minutes. After the incubation period 5 ml of Griesss reagent was added then absorbance was taken at 546 nm. A blank was prepared without adding extract. Curcumin at various concentrations was used as standard, % reduction and IC50 were calculated [21].

2.4 Experimental Animals

Adult Swiss albino mice weighing 18-22 gm and wistar rats 200-230 gm of either sex obtain from Zydus Research Centre, Ahmedabad, for experimental purpose were all acclimatized for 7 days under standard husbandry conditions i.e.; room temperature of (25±1)ºC; relative humidity of 45%-55% and a 12:12 h light/ dark cycle.

2.4.1 Acute oral toxicity studies

The acute oral toxicity study of MLPO was carried out in Swiss albino mice (20-25 gm) and wistar rats (200-230 gm), using the Organization for Economic Co-operation and Development (OECD) guidelines (OECD 423). The animals received a single dose of 2000 mg/kg orally by gavages and were observed for toxic symptoms and mortality, continuously for first 4 h after dosing. Finally, the number of survivors was noted after 24 hrs and these animals were then maintained for further 14 days with observations made daily.

2.4.2 Haloperidol induced catalepsy in mice

Albino mice of either sex weighing 20-25 gm were divided into five groups of six animals each (n=6). The animals were allowed to adapt to the box for 2 min. A cataleptic behavior was measured with a "High bar test method". The standard (L-dopa) drug was administered by intraperitoneal route and test drug was administered by oral route, half an hour prior to the haloperidol administration. Catalepsy score was measured for each hour upto 4 h after Haloperidol administration, by gently placing both the forepaws of the mice over a metal bar (diameter 2-5 mm) suspended 6 cm above the table top. The intensity of catalepsy was assessed by counting time in seconds until the mice brought both forepaws down to the table top, with a maximum cut-off time of 180 seconds [22].

2.4.3 Haloperidol induced orofacial dyskinesia in rat

Dyskinesia is characterized by vacuous chewing & tongue protrusion. Wistar rat of either sex weighing 200-230 gm were divided into five groups of six animals each (n=6). Haloperidol was administered in the rats for a period of 21

days to induce oral dyskinesia. Test agent was administered once daily in the morning for a period of 21 days and behavioral assessments was performed at 7^{th}, 14^{th}, 21^{th} day [22].

2.5 Statistical Analysis

Values were expressed as mean ± SEM from 6 animals. Statistical difference in mean will be analyzed using one way ANOVA followed by Turkey's multiple comparison tests $P < 0.05$ were considered statically significant.

3. RESULTS AND DISCUSSION

3.1 Phytochemical Analysis

The phytochemical studies of methanolic extract of *Portulaca oleracea* seed (MLPO) revealed presence of carbohydrates, alkaloids, glycosides, saponins, tannins and phenolic compounds proteins & free amino acids, flavanoids, and phenolic compounds.

3.2 Determination of Total Polyphenols

The estimation of polyphenolic content was performed by based on primary phytochemical investigation by Folin- Ciocalteu's reagent, the extracts exhibit that, the MLPO found to contain 96.38%. Brief results are shown in Table 1.

3.3 Antioxidant Activity

The extracts containing varying quantities of total polyphenols were comparatively studied for their antioxidant potentialities. Two different *in vitro* methods namely Reducing Power by $FeCl_3$ and Nitric Oxide Free Radical Scavenging activity were employed, ascorbic acid was used as a standard in Reducing Power by $FeCl_3$, the MLPO significantly decreased the absorbance and the IC50 value 182.02±9.64 µg/ml was found, to possess more significant antioxidant activity, however the IC50 value is lesser then ascorbic acid.

In Nitric Oxide Free Radical Scavenging activity, Curcumin, was used as a standard, MLPO has offered good free radical scavenging activity by decreasing the absorbance and the IC50 value 667.12±16.02 µg/ml the IC50 value is lesser then Curcumin. IC50 value of different antioxidant activity of *Portulaca oleracea* seed methanolic extract (MLPO) was shown in Table 2.

3.4 Acute Toxicity Studies

The acute oral toxicity (AOT) study of MLPO was observed that it was safe upto 2000 mg/kg body weight and it was not showing any mortality, based on AOT selected dose for Anti-Parkinson activity were 200 mg/kg body weight and 400 mg/kg body weight.

3.5 Haloperidol Induced Catalepsy in Mice

Treatment with L-dopa (10 mg/kg, i.p) showed a significant ($P<0.01$) reduction in the cataleptic behavior between 60 to 180 min of time interval as compared to the haloperidol treated group. Treatment with *Portulaca oleracea* seed showed a significant ($P<0.01$) reduction in the duration of cataleptic behavior dose dependently when compared to haloperidol treated group. Brief results are given in Table 3.

Table 1. Quantitative determination polyphenols at 760 nmative determination polyphenols

Sr. no.	Extract	Polyphenols (%)
01	Methanolic extract of *Portulaca oleracea* seed (MLPO)	96.38 %

Table 2. IC50 value of different antioxidant activity

Sr. no.	Antioxidant determining method	IC50 value of ascorbic acid (µg/ml) ± S.D	IC50 value of curcumin (µg/ml) ± S.D	IC50 value of extract MLPO (µg/ml) ± S.D
01	Reducing power by FeCl3	15.78±1.87	----------	182.02±9.64
02	Nitric oxide free radical scavenging activity	----------	41.37±5.05	667.12±16.02

Value are mean ± S.D.; n=3

Table 3. Effect of *Portulaca oleracea* seed (MLPO) in haloperidol induced catalepsy in mice

Sr. no.	Treatment	Catalepsy score (in seconds)				
		00	60	120	180	240
1	Vehicle	15.64±0.21	15.76±1.34	15.53±0.43	16.36±0.96	13.98±1.18
2	Haloperidol (1.0 mg/kg i.p.)	16.22±6.50	164.19±4.69^{c}	167.27±5.14^{c}	173.62±5.12^{c}	143.93±6.24^{c}
3	L-dopa (10 (mg/kg, i.p.)	15.17±6.68	57.236±2.135^{b}	54.305±5.485^{b}	44.20±2.80^{b}	121.43±3.29^{ns}
4	MLPO200 (mg/kg, p.o.)	16.48±3.67	118.36±2.25	101.00±3.76^{a}	111.24±1.71^{a}	139.13±3.18^{ns}
5	MLPO400(mg/kg, p.o.)	13.71±2.54	68.26±1.46^{b}	47.39±3.36^{b}	87.73±34.69^{a}	124.51±3.51^{ns}

The values are expressed as mean ±SEM (n=6); ^{a}P<0.05, ^{b}P<0.01, vs Haloperidol group (One way ANOVA followed by Dunnett's test. ^{c}P<0.001 vs vehicle group, ns-Non significant (Students't' test)

Table 4. Effect of *Portulaca oleracea* seed (MLPO) on haloperidol induced orofacial dyskinesia in wistar rat

Sr. no.	Treatment	Treatment Frequency of movement/15 min					
		Vacuous chewing movement (VCM)			Tongue protrusion		
		Day 7	Day 14	Day 21	Day 7	Day 14	Day 21
1	Vehicle	0.35±0.29	0.40±0.17	1.28±0.55	0.29±0.25	0.55±0.27	0.58±0.29
2	Haloperidol(1.0 mg/kg i.p.)	2.65±0.32	2.65±0.46^{c}	4.24±1.13	2.76±0.28	4.93±1.91^{c}	6.83±0.35^{c}
3	L-dopa (10 (mg/kg, i.p.)	0.96±0.54^{a}	0.56±0.25^{b}	1.53±0.41^{b}	0.65±0.23^{b}	1.58± 0.52^{b}	1.64±0.22^{b}
4	MLPO 200 (mg/kg, p.o.)	1.97±0.62^{ns}	1.76±0.44^{ns}	3.94±0.55^{ns}	1.73±0.54^{ns}	4.86±1.35^{ns}	3.87±0.67^{a}
5	MLPO 400(mg/kg, p.o.)	172.41±0.35^{ns}	0.83±0.34^{b}	2.23±0.61^{b}	1.43±0.11^{b}	2.12±1.23^{a}	2.76±0.51^{b}

The values are expressed as mean±SEM (n=6); aP<0.05, bP<0.01 vs Haloperidol group (One way ANOVA followed by Dunnett's test). CP<0.001 vs vehicle group, ns-Non significant

3.6 Haloperidol Induced Orofacial Dyskinesia in Rat

L-dopa (10 mg/kg, i.p.) showed a significant ($P<0.05$) recovery of orofacial dyskinesia as evidenced by decrease in the frequency of vacuous chewing movement and tongue significant ($P<0.05$) decrease in the frequency of vacuous chewing & tongue protrusion while *Portulaca oleracea* seed (200 mg/kg) was found to be insignificant in this respect. Brief result is shown in Table 4.

Animal models of Parkinson's disease are widely used to investigate its pathophysiological mechanisms and for exploring treatments. Typically, models of PD are characterized by measures of akinesia, such as in bar test for immobility, such as test for immobility [23,24,5].

Narcoleptics such as haloperidol can produce a sustained but reversible akinesia, due to blockade of dopamine D_2 receptors and this neuroleptic-induced Parkinsonism is a major side effect of their use in treatment of schizophrenia. D_2 antagonists may act directly to reduce the ability of cortical and basal ganglia motor pathways. Neuroleptics have thus been used as an acute model of Parkinson [25]. The central dopaminergic function and evaluation of dopamine agonistic activity was performed by observing the cataleptic behavior in mice [5]. Haloperidol blocks the dopamine D_2 receptors in the brain and precipitates the extra pyramidal side effects that can be measured by "Bar test for catalepsy in mice".

Oral movement is an primary as well as important symptom presented by a series of neuropsychiatric conditions including Parkinson's disease [26,27]. In addition, a spontaneous aging-induced oral dyskinesia has been extensively described. Thus, oral dyskinesia might be representing the behavioral manifestation, resulting from underlying mechanisms shared by different neuropsychiatric conditions. Tardive Dyskinesia is a motor side effect of long term treatment with typical neuroleptics (such as haloperidol) that involves involuntary movements of the face, mouth and tongue, but other different parts of the body may also be affected [28]. Treatment with L-dopa (10 mg/kg, i.p.) significantly attenuated the dyskinetic behavior in rats. *Portulaca oleracea* seed (MLPO) showed a significant attenuation in the frequency of tongue protrusions & Vacuous chewing movement (VCM) at higher doses tested.

Dopamine metabolites, along with a reduction in dopamine receptor activation. During this process, hydrogen peroxide is thus formed and becomes an important source of oxidative stress in catecholaminergic neuronal systems [29]. Some study states that Haloperidol neurotoxicity to the inhibition of mitochondrial electron transfer with an enhancement of O_2 and H_2O_2 production [30]. Reactive Oxygen Species (ROS) originating from the oxidation of Dopamine (DA) further participates in the pathogenesis of PD. Oxidative stress generated as a result of mitochondrial dysfunction; particularly mitochondrial complex-1 impairment plays an important role in the PD pathogenesis [31]. Probably, there is not a single factor responsible for neurodegeneration; it appears that several factors are acting in concert. Oxidative stress and consequent cell death could occur in the substantia nigra pars compacta (SNpc) under circumstances in which there is (a) an increased dopamine turnover, resulting in excess peroxide formation; (b) a deficiency in glutathione (GSH) content, thereby diminishing the brains capacity to clear H_2O_2 or (c) an increase in reactive iron species, that can promote hydroxyl radical formation [32].

4. CONCLUSION

The treatment *Portulaca oleracea* seed (MLPO), exhibit significant alterations in Parkinson's affected rodents with respect to antioxidant concentration hence signifies its antioxidant potential. This antiperoxide action observed in *Portulaca oleracea* seed (MLPO) treated animals might be due to the suppression of the production of reactive oxygen species. The MLPO may be scavenge free radicals, including hydroxyl anions and reduce the level of lipid peroxidation in MLPO animals and Inhibition of oxidative stress may be one of the possible mechanisms for the anti-Parkinson effects of *Portulaca oleracea* seed (MLPO).

CONSENT

It is not applicable.

ETHICAL APPROVAL

The experimental protocols was approved by Institutional Animal Ethical Committee (IAEC) of C.U. Shah College of Pharmacy and Research, Surendranagar (Gujarat) and were conducted in strict compliance according to ethical principles

and guidelines provided by Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA).

ACKNOWLEDGEMENTS

The authors are thankful to Dr. J. G. Sanghvi, Chairman and management members of C.U. Shah College of Pharmacy and research for providing all necessary facilities to carry out the research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Lev N, Melamed E, Offen D. Apoptosis and Parkinson's disease. Prog Neuropsychopharmacol Biol Psychiatry 2003;27(2):245-50.
2. Singha S, Dikshit M. Apoptotic neuronal death in Parkinson' involvement of nitric oxide. Brain Res Rev. 2007;54(2):233-250.
3. Emerit J, Edeas M, Bricaire F. Neurodegenerative diseases and oxidative stress. Biomed Pharmacother. 2004;58(1): 39-46.
4. Ciccone CD. Free-radical toxicity and antioxidant medications in Parkinson's disease. Phys and Ther. 1998;78(3):313-319.
5. Kabra MP, Bhandari SS, Sharma A, Gupta RB. Evaluation of Anti-Parkinson's activity of gentisic acid in different animal models. Journal of Acute Disease. 2014;3(2):141-144.
6. Chatterjee A, Chandra S. The treatise on Indian medicinal plants. Publ Informa Directorate. 1956;1:243-44.
7. Kole PL, Jadav H, Thakurdesi P. The cosmetic potential of herbal extract. Nat Prod Radiat. 2005;4(4):351-352.
8. Uddin MK, Juraimi AS, Anwar F, Hossainm A, Alam MA. Effect of salinity on proximate mineral composition of purslane (*Portulaca oleracea* L.). Australian Journal of Crop Science. 2012;6(12):1732-1736.
9. Liu LX, Howe P, Zhou YF. Fatty acid and B carotene in Australian Pursalne. J Chromatogr. 2000;893(1):207-13.
10. Chen HB, Zhou W, Zhao W, Zhou Q, Uan G. Effects of aqueous extract of *Portulaca oleracea* L. on oxidative stress and liver, spleen leptin, PAR and FAS mRNA expression in high-fat diet induced mice. Molecular Biology Reports. 2012;39(8): 7981-7988.
11. Mohamed Dkhil A, Moneim E, Al Nasr I. Nuronal activities of *Portulaca oleracea* in adult rats. J of Medicinal Plant Res. 2012;6(16):3162-68.
12. Yue ME, Jiang TF, Shi YP. Simultaneous determination of noradrenaline and dopamine in *Portulaca oleracea* L. by capillary zone electrophoresis. Journal of Separation Science. 2005;28(4):360–364.
13. Nadkarni KM, Nadkarni AK. Indian Materia Medica. Popular Prakashan, Mumbai; 1999.
14. Chan K, Islam MW, Kamil M. The analgesic and anti-inflammatory effects of *Portulaca oleracea* L. subsp. Sativa (Haw.) Celak. Journal of Ethnopharmacology. 2000;73(3):445-451.
15. Liu l, Peter H, Ue-Fang Z, Zhi-Qiang X, Charles H, Ren Z. Fatty acids and b-carotene in Australian Purslane (*Portulaca oleracea*) varieties. Journal of Chromatography. 2000;893:207-213.
16. Rangari VD. Pharmacognosy & Phytochemistry. 8th Ed. Nashik: Career Publication; 2008.
17. Harbone JR. Phytochemical methods: A guide to modern techniques of plant analysis. Science Paperbacks; 1984.
18. Golwala DK, Patel LD. Pharmacognostical Studies of *Bauhinia variegate* Linn. Stem International J. of Pharmaceutical Res. 2012;4(4):1-4.
19. Vaidya SK, Bothara SB. Total Polyphenolic content and *In-vitro* antioxidant potential of extracts of creeping herb *Ipomoea reniformis (Roxb.) Choisy*. American J. of Phytomed and Clin. Therapeutics. 2014;2(12):1462-1469.
20. Bhalodia NR, Pankaj B, Nariya R, Acharya N, Shukla VJ. *In vitro* antioxidant activity of hydro alcoholic extract from the fruit pulp of *Cassia fistula* Linn. Ayurveda. 2013; 34(2):209-214.
21. Boora F, Chirisa E, Mukanganyama S. Evaluation of nitrite radical scavenging properties of selected Zimbabwean plant extracts and their phytoconstituents. J of Food Processing. 2014;1-7.
22. Vogel HG, Vogel WH, Scholkens BA, Sandow J, Muller G. Drug discovery and evaluation, pharmacological assays. 2nd Ed. Heidelburg: Springer; 2002.

23. Dawson TM. New animal models for Parkinson's disease. Cell. 2000;101:115-118.
24. Rodriquez DM, Abdala P, Barroso-Chinea P, Obeso J, Gonzdez-Hernandez T. Motor behavioral changes after intracerebroventricular injection of 6-hydroxy dopamine in the rat: An animal model of Parkinson's disease. Behav. Brain Res. 2001;122(1):79-92.
25. Chandra S, Chen X, Rizo J, Jahn R, Sudho TC. A broken α helix in folded α synuclein. J Biol. Chem. 2003;278(17): 15313-15318.
26. Jicha GA, Salmone JD. Vacuous jaw movements and feeding deficits in rats with ventrolateral striatal dopamine depletion: Possible relations to Parkinsonian symptoms. J Neurosci. 1991;11(12):3822-3829.
27. Paille V, Brachet P, Damier P. Role of nigral lesion in the genesis of dyskinesias in a rat model of Parkinson's disease. Neuroreport. 2004;15(3):561-564.
28. Marin C, Saldana M, Roca-Ferrer J, Bonastre M, Aguilar E, Mullol J. Striatal and nigral COX-2 expression after chronic typical and atypical neuroleptic administration in rats. Prog. Neuro-Psychopharmacol. Biol. Psychiat. 2007;31: 678-682.
29. Lohr JB. Oxygen free radicals and neuropsychiatric illness. Arch Gen Psychiat. 1991;48(12):1097-1106.
30. Arniaz SL, Coronel MF, Boveris A. Nitric oxide, superoxide, and hydrogen peroxide production in brain mitochondria after haloperidol treatment. Nitric Oxide. Schizophrenia Bulletin. 2004;30(4):235-243.
31. Nehru B, Verma R, Khanna P, Sharma SK. Behavioral alterations in model of Parkinson's diseases: Attenuation by cotreatment of. Brain Res. 2008;1201:122-127
32. Jenner P. Oxidative mechanisms in Nigral cell death in Parkinson's disease. Mov Disord. 1998;13(1):24-34.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/54927