*Journal of Medicine & Biomedical Research*

# A MINI REVIEW ON NEUROPROTECTIVE EFFECTS OF SYZYGIUM CUMINI

*Zhen Ji Lai[1], Yin Yin Ooi[2], Anna Pick Kiong Ling[1], Soi Moi Chye[1], Rhun Yian Koh[1,*]*


## ABSTRACT

World Health Organization (WHO) in 2015 reported the prevalence of neurodegenerative diseases to be unacceptably high, with 3 out of 100 persons encountering neurological problems. Chemically synthesised drugs are available for the control of the diseases. However, use of the drugs is associated with unwanted side effects, thus, stimulating interest in the quest for natural neuroprotective substances to replace these drugs. *Syzygium cumini* is a medicinal plant that is often used in Nigeria for the treatment of inflammation, diabetes mellitus, pain, diarrhoea and ulcer. Different parts of the plant such as leaves, seed, fruit and stem have been claimed to show neuroprotection effects but much needs to be done in evaluating its role and therapeutic efficacy in neurodegenerative diseases. This review will focus on the neuroprotective effects of *Syzygium cumini*.


**Keywords:** *Syzygium cumini*, Neuroprotection, Neurodegenerative diseases

## INTRODUCTION

Neurodegenerative diseases (NDDs) are characterised by the irreversible and progressive damage of neuronal structure and function. These diseases primarily correlate with age. Parkinson's and Alzheimer's diseases are the most prevalent neurological problems in the elderly. Alzheimer's disease (AD) is associated with the aggregation of two proteins in the Hippocampus - Neurofibrillary tangles and Amyloid β (Aβ) plaques that are made of tau protein which lead to memory loss and progressive neurocognitive dysfunction. Parkinson's disease (PD) is characterised by dopaminergic neuronal death of the substantia nigra pars compacta, with the accumulation of Lewy bodies and Lewy neurites due to the presence of ơ-synuclein. Besides genetic problems and protein aggregation, NDD can be caused by oxidative stress, inflammation and excitotoxicity[1]. People with AD experience memory loss, personality and mood changes, inappropriate paroxysm of anger, increased sleeping and moaning[2]. The most identifiable signs of PD include tremor, bradykinesia, impaired balance and slurred speech[3].

Conventional therapies such as L-dopamine for PD and cholinesterase inhibitors for AD are often consumed but show minimal effects on disease progression. Integrative medicine is used to improve the quality of life of NDD patients by regulating all the related symptoms and treating the acute symptoms[4]. For instance, mangosteen which originated from Southeast Asia contains nutraceuticals that exert favourable impacts, especially antioxidative, neuroprotective and anti-inflammation effects which are able to reduce cell death and raise levels of neurotrophic factor in the brain[5]. Stem cell transplantation seems to restore the damage

*Zhen Ji Lai[1], Yin Yin Ooi[2], Anna Pick Kiong Ling[1], Soi Moi Chye[1], Rhun Yian Koh[1,*]*

[1]*Division of Applied Biomedical Science and Biotechnology, School of Health Sciences, International Medical University, Bukit Jalil, 57000 Kuala Lumpur, Malaysia.*

[2]*School of Biosciences, Faculty of Health & Medical Sciences, Taylor's University, 47500 Subang Jaya, Selangor, Malaysia.*

***Correspondence:***
***Rhun Yian Koh.***

*Division of Applied Biomedical Science and Biotechnology, School of Health Sciences, International Medical University, Bukit Jalil, 57000 Kuala Lumpur, Malaysia.*
*Email address: rhunyian_koh@imu.edu.my*
*Contact number: +603-27317207*

of neuron cells; however the issue of ethical question and expensive fees have been the main drawbacks[6]. Hence, complementary and alternative medicine such as medicinal plant is required as an alternative way to treat NDD.

Recent advances in medicinal plant research suggest that *Syzygium cumini* may provide an opportunity as an alternative treatment for NDD as it has neuroprotective effects[7]. Neuroprotection is defined as mechanisms and methods to preserve the nervous system against injury. *Syzygium cumini*, also known as Indian blackberry or jambolana is an evergreen tropical shrub that originates from India and widely distributed in Asian countries. The lower part of its bark is thick and discoloured while the upper part is smooth with light-greyish colour. Its leaves are 5-25 cm long, elliptic and opposite with turpentine smell. Its fruits are berries which are edible with astringent taste. The fruits contain 2 to 5 ovoid-oblong and dark purple colour seeds. Its sessile yellowish flowers with funnel-shaped calyx consist of 4-5 petals. The seeds and fruits are known to have pain relieving, diuretic, anti-scorbutic and carminative effects. In Far East, the seeds and bark are utilised in the management of diabetes mellitus[8]. Jamun's fruit is a good source of iron that acts as a blood purifier as it enhances the flow of oxygenated blood throughout the body. The seed of the fruit is well-known in various alternative medicines such as Ayurveda, Chinese medicine and Unani in maintaining the blood glucose level and it is more effective compared to glibenclamide[9].

Figure 1 shows pictures of different aspects of *Syzygium sumini*[10]. Taxonomic classification of *Syzygium cumini* is as indicated below**:**
Kingdom: Plantae,
Phylum: Magnoliophyta,
Class: Magnoliopsida,
Order: Myrtales,
Family: Myrtaceae,
Genus: Syzygium and
Species: cumini.

This review will focus on the neuroprotective effects of *Syzygium cumini*.

## MAJOR ACTIVE COMPOUNDS OF *SYZYGIUM CUMINI*

### Anthocyanin

Anthocyanin is compound found in the pulp of Jamun[11]. Anthocyanin-enriched foods provides several health advantages including decreased risks of coronary heart disease, cancer and obesity as well as build-up of memory[12]. Anthocyanin was shown to relieve nigra dopaminergic cell loss and motor deficit as it displays anti-apoptotic effects on neurons. The antioxidant property of anthocyanin, especially at the level of mitochondria has been shown to support its neuroprotective activities[13,14]. Anthocyanin can be extracted by different methods. Ethanol with 1% hydrochloric acid (HCl) was used to extract anthocyanin from the fruit of *Syzygium cumini*, while the other phenolic compounds were extracted with methanol/water (8:2, v/v). Furthermore, functional extraction was carried out by using ethanol with 5% phosphoric acid ($H_3PO_4$), in which anthocyanin in the extract was acquired with the acidifying agent. This procedure was followed by separation and analysis using high performance liquid chromatography coupled to the diode array and mass spectrometer detectors (HPLC-DAD-MS/MS). The anthocyanin was shown to have lower concentration in functional extract than those found in the fruit. Besides, the results suggested that anthocyanin extraction by the utilisation of phosphoric acid is less efficient when compared to HCl[15]. Another study that analysed anthocyanin using pH-differential techniques demonstrated that the Jamun's pulp powder extracted with aqueous ethanol containing HCl consist of 0.54% anthocyanin. Enrichment of anthocyanin was performed by loading the concentrated extract on a XAD-761 (Amberlite polymeric adsorbent of 20-50 mesh) and diaion HP-20 column. XAD-761 was selected due to its high affinity for anthocyanin. However, the enrichment did not enhance the anthocyanin content. Hydrolysis of the enriched pulp extracts yielded 0.23% of anthocyanidin, the

sugar-free counterparts of anthocyanin. Unlike the pulp extracts, there was no anthocyanin detected in the seed extracts.

**Gallic acid**

Gallic acid (GA) is a polyphenol found in the leaves and seeds of *Syzygium cumini*[16,17]. The aqueous seeds extract was prepared by extracting the seed powder with distilled water under reflux for 1 hour. In the case of aqueous leaves extract, the leaves were dried at 40°C for 2 days and then were ground in a knife mill and sent to extraction until exhaustion. The presence of gallic acid was measured by high-performance liquid chromatography with diode array detector (HPLC-DAD) and the HPLC fingerprinting of both extracts showed that GA is the major component of the extracts[18]. Cargnelutti *et al.* (2015) and Bitencourt *et al.* (2016) both suggest that GA is found in high quantity in aqueous leaves and seeds extracts of *Syzygium cumini*[19,20]. A paper published by Amudha *et al.* (2016) showed that hydroethanolic seed extract of *Syzygium cumini* contained the highest amount of gallic acid followed by aqueous extract and raw seed powder which are 48.73, 20.66 and 5.85 mg/gm, respectively[21]. Gallic acid is able to impede the acetylation of nuclear factor kappa B (NF-κB) which then suppresses the microglia from synthesising cytokine and protects neurons from Aβ-induced toxicity via decreasing the acetylation of RelA. Hence, gallic acid was shown to be a potential therapeutic approach against AD[22]. This hypothesis was supported by the reduction of p66shc protein expression and anisomycin-induced Aβ1-42 production in SH-SY5Y cells after treatment with Gallic acid. Gallic acid treatment also resulted in the elevation of superoxide dismutase (SOD) activity and secretion of acetylcholine[23].

## NEUROPROTECTIVE EFFECTS OF *SYZYGIUM CUMINI*

**Neuroprotection by acetylcholinesterase inhibition**

Acetonic powder extract prepared from leaves of *Syzygium cumini* was mixed with a solution of acetylcholinesterase (AChE), phosphate buffer, and Ellman's reagent (DTNB). Acetylthiocholine iodine solution was added after 20 minutes of incubation at 25°C. The absorbance was determined at 412 nm by spectrophotometer and the activity was determined by a colourimetric method[24]. The procedure was repeated for butyrylcholinesterase (BChE) inhibitory activity by using butyrylcholinesterase iodide as a substrate. The AChE or BChE inhibitory effect was shown to increase in a dose-dependent manner as concentrations of the extract increased. The AChE produces acetic acid and Choline from the hydrolysis of acetylcholine, leading to the terminus of the synaptic cholinergic neurotransmission. AChE influences the learning and memory abilities by inhibiting the N-methyl- D-aspartate receptor (NMDAR) in hippocampus[25].

In another study, *Syzygium cumini* seeds were powdered and extracted with hexane to eliminate lipids followed by vacuum filteration. The maceration method was employed in which the residue was further extracted by methanol. Five groups of male Albino Wistar rats, each group with 6 rats at about 6-8 weeks were formed. Rats in group 1 received only vehicle while group 2 rats received scopolamine to induce amnesia in the animals. Rats were treated with piracetam (standard drug), 200 and 400 mg/kg of methanolic extract in group 3, 4 and 5, respectively against scopolamine-induced amnesia. The extracts demonstrated anti-amnesia activity in the animals due to inhibition of AChE activity[26]. Inhibition of AChE activity may enhance dendritic arborisation synaptogenesis[27-29]. A study reported that the impaired memory function was associated with elevated AChE activity along with increased glucocorticoid levels in brain of stressed rats[30]. Another study further explained that the elevation of glucocorticoid levels are caused by the dis-inhibition of hypothalamus-pituitary gland-adrenal gland (HPA)-axis due to blockade of muscarinic acetylcholine receptor (mAChR) resulting in down-regulation of mineralocorticoid receptor (MR) and glucocorticoid receptor (GR)[31].

Plants with antioxidant property have been shown to possess neuroprotection potential. Various studies have shown that *Syzygium cumini* has potent antioxidative effect *in vitro*[32,33]. Infusion extract (IE) of *Syzygium cumini* was prepared by soaking the powdered leaves with distilled water while aqueous extract (AE) and hydroalcoholic extract (HAE) were prepared by mixing leaves with water and 50% ethanol, respectively. These extracts were sonicated and concentrated in a rotator evaporator. Different concentrations of the three extracts were added to the solution of 1,1-diphenyl-2-picrylhadrazyl (DPPH) in ethanol and Mill-Q water according to the modified strategy of Choi *et al.* (2002)[34]. The ability of these extracts to scavenge the DPPH radicals was measured using spectrophotometer. All three extracts expressed a potential dose-dependent DPPH scavenging activity in which AE and HAE exhibited greater antioxidant effects than IE[35]. In another study, pulp and seed powders of *Syzygium cumini* were extracted by acidified aqueous ethanol. Hydrolysis of extracts using HCl was performed to convert glycones present in extracts to aglycones (e.g., anthocyanin to anthocyanidin). From the results of DPPH assay, unhydrolysed seed extract exhibited better inhibition (up to 90%) in compared to hydrolysed seed. The concentration of extracts that quenched 50% of DPPH differed as the following: unhydrolysed seed extract, 16.3 µg/ml; hydrolysed seeds, 19.8 µg/ml; hydrolysed fruit, 79.0 µg/ml and unhydrolysed pulp, 90.0 µg/ml. Previous study showed that the phenolic and flavonoid components are fundamental in the scavenging of free radicals. The vicinal trihydroxyl group and catechol group provide a significant contribution on radical scavenging capacity for *Syzygium cumini*[12]. Their chemical structure and redox properties allow them to act as reducing agents and hydrogen donors, contributing to the synthesis of less reactive radicals, chelating transitional metals, and suppressing lipoxygenase[36]. The disappearance of DPPH in its radical form on reduction into a stable diamagnetic molecule explained the hydrogen donating ability of *Syzygium cumini*[37].

In an animal study, corticohippocampal of *Syzygium cumini* seed extract-administered rats showed significantly lowered lipid peroxide (LPO) values than the control rats[38]. The method of Ohkawa *et al.* (1979) was employed to determine the LPO content by mixing brain tissue homogenate with thiobarbituric acid in acetic acid, sodium dodecylsuphate, and distilled water. The content was heated for 1 hour and cooled followed by the addition of n-butanol-pyridine. The absorbance of content was determined at 532 nm with spectrophotometer[39]. In the study, rats with hypoxia-induced oxidative stress rats that were pre-treated with seeds extracts showed less cell swelling. In addition, the seed extracts of *Syzygium cumini* exhibited a preservative effect against cellular damages in the corticohippocampal brain tissues and downregulated LPO levels in these brain regions[38]. Antioxidative effects could be attributed to the ability of *Syzygium cumini* in increasing enzymes such as superoxide dismutase, glutathione (GSH), catalase and gluthathione peroxidase[40]. A study performed by Kabuto *et al.* (2007) indicated that eugenol, a compound that can be found in *Syzygium cumini*, was effective against 6-hydroxydopamine (6OHDA)-induced neurotoxicity by inhibiting the synthesis of dopamine, 3,4-diphydroxyphenylacetic acid (DOPAC), homovanilic acid (HVA) and lipid peroxidation in dopaminergic neurons of mouse striatum. The study showed that the mouse striatum homogenate that was treated with eugenol showed lowered thiobarbituric acid reactive substances (TBARS) level than that of the control group. The study showed that the up-surged of GSH, L-ascorbate, and, to a lesser degree, eugenol, simultaneously may promote antioxidant stress activity and protective effects on dopaminergic neurons against 6-OHDA neurotoxicity[41].

**FIGURE**

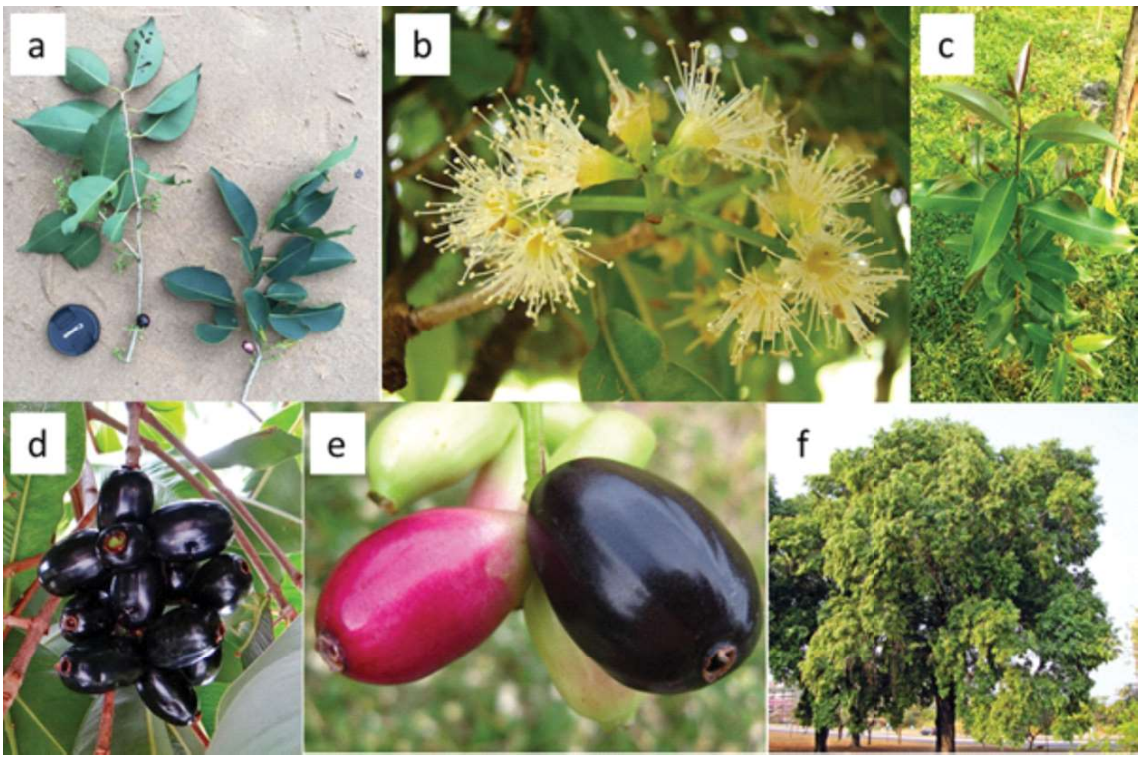


Figure 1: *Syzygium cumini*. (a) Leaves, (b) flowering phase, (c) plant before flowering, (d,e) fruits and (f) tree.(10)

## CONCLUSION

*Syzygium cumini* possesses high amount of anthocyanin and polyphenols such as gallic acid which have potential antioxidant properties. The phenolic and flavonoid contents of the *Syzygium cumini* extracts account for the free-radical scavenging and AChE or BChE inhibitory activities. The beneficial effects of *Syzygium cumini* were accompanied with the repression of LPO and Aβ levels in the brain. The literature suggests that *Syzygium cumini* could be an alternative therapeutic agent in restraining or decelerating the progress of age-associated oxidative stress-related NDDs such as AD and PD. Further research is required to define the toxic effects of *Syzygium cumini* and validation of the use of *Syzygium cumini* by clinical trials.

## REFERENCES

1. Sardoiwala MN, Kaundal B, Choudhury SR. Development of engineered nanoparticles expediting diagnostic and therapeutic applications across blood-brain barrier. In: Handbook of Nanomaterials for Industrial Applications. 2018.

2. Li X-L, Hu N, Tan M-S, Yu J-T, Tan L. Behavioral and psychological symptoms in Alzheimer's disease. Biomed Res Int. 2014;2014:927804.

3. DeMaagd G, Philip A. Parkinson's Disease and Its Management: Part 1: Disease Entity, Risk Factors, Pathophysiology, Clinical Presentation, and Diagnosis. P T. 2015 Aug;40(8):504–32.

4. Chen X, Pan W. The Treatment Strategies for Neurodegenerative Diseases by Integrative Medicine. Integr Med Int. 2014;1(4):223–5.

5. Cooper EL, Ma MJ. Alzheimer Disease: Clues from traditional and complementary medicine. J Tradit Complement Med. 2017 Oct;7(4):380–5.

6. Pen AE, Jensen UB. Current status of treating neurodegenerative disease with induced pluripotent stem cells. Acta Neurol Scand. 2017 Jan;135(1):57–72.

7. Karasawa MMG, Mohan C. Fruits as Prospective Reserves of bioactive Compounds: A Review. Nat Products Bioprospect. 2018 Oct;8(5):335–46.

8. Sabino L, Brito E, Júnior I. Jambolan— Syzygium jambolanum. In Exotic Fruits. Academic Press.2018. p. 251–256.

9. Rakesh R Shukla. Jambu (Syzygium cumini) – A fruit of gods. Ayurpharm Int J Ayur Alli Sci. 2013;2(4):86-91.

10. Sah AK, Verma VK. Syzygium cumini: An overview. J Chem Pharm Res. 2011;3(3):108–13.

11. Ramya S, Neethirajan, K Jayakumararaj R. Profile of bioactive compounds in Syzygium cumini. J Pharm Res. 2012;5(8):4548–53.

12. Aqil F, Gupta A, Munagala R, Jeyabalan J, Kausar H, Sharma RJ, et al. Antioxidant and antiproliferative activities of anthocyanin/ellagitannin-enriched extracts from Syzygium cumini L. (Jamun, the Indian Blackberry). Nutr Cancer. 2012 Apr;64(3):428–38.

13. Roghani M, Niknam A, Jalali-Nadoushan M-R, Kiasalari Z, Khalili M, Baluchnejadmojarad T. Oral pelargonidin exerts dose-dependent neuroprotection in 6-hydroxydopamine rat model of hemi-parkinsonism. Brain Res Bull. 2010 Jul;82(5–6):279–83.

14. Ross EK, Kelsey NA, Linseman D. Anthocyanins: Janus Nutraceuticals Displaying Chemotherapeutic and Neuroprotective Properties. In Nutral Compounds as Inducers of Cell Death, Diedrich M, Nowortyta K. (eds) Springer. 2012; 491-513

15. Faria AF, Marques MC, Mercadante AZ. Identification of bioactive compounds from jambolão (Syzygium cumini) and antioxidant capacity evaluation in different pH conditions. Food Chem. 2011 Jun;126(4):1571–8.

16. Prince PS, Menon VP, Pari L. Hypoglycaemic activity of Syzigium cumini seeds: effect on lipid peroxidation in alloxan diabetic rats. J Ethnopharmacol. 1998 May;61(1):1–7.

17. Eidi A, Eidi M, Esmaeili E. Antidiabetic effect of garlic (Allium sativum L.) in normal and streptozotocin-induced diabetic rats. Phytomedicine. 2006 Nov;13(9–10):624–9.

18. Borges RM, Bitencourt PER, Stein C, Bochi G, Boligon A, Moresco R, et al. Leaves and seeds of Syzygium cumini extracts produce significant attenuation of 2 , 2 azobis-2-amidinopropane dihydrochloride-induced toxicity via modulation of ectoenzymes and antioxidant activities. J Appl Pharm Sci. 2017; 7: 37-48

19. Cargnelutt LO, Bitencourt PR, Bochi G, Duarte T, Boligon AA, Pigatto A, et al. Syzygium cumini Leaf Extract Protects Against Ethanol-Induced Acute Injury in Rats by Inhibiting

Adenosine Deaminase Activity and Proinflammatory Cytokine Production. Res J Phytochem. 2015;9:56–67.

20. Bitencourt PR, Ferreira L, Cargnelutti LO, Denardi L, Boligon AA, Fleck MA, et al. A new biodegradable polymeric nanoparticle formulation containing Syzygium cumini: Phytochemical profile, antioxidant and antifungal activity and in vivo toxicity. Ind Crops Prod. 2016;83:400–7.

21. Amudha S, P. K. Manna, Jeganathan N.S AS. Estimation of Gallic Acid in the Seed Extracts of Syzygium cumini. Asian J Pharm Technol Innov. 2016;04(21):40–4.

22. Kim M, Seong A, Yoo J-Y, Jin C-H, Lee Y, Kim Y, et al. Gallic acid, a histone acetyltransferase inhibitor, suppresses β-amyloid neurotoxicity by inhibiting microglial-mediated neuroinflammation. Mol Nutr Food Res. 2011;55 12:1798–808.

23. Wang Y, Liu T, Pan W, Chi H, Chen J, Yu Z, et al. Small molecule compounds alleviate anisomycin-induced oxidative stress injury in SH-SY5Y cells via downregulation of p66shc and Aβ1-42 expression. Exp Ther Med. 2016;11 2:593–600.

24. Ellman G, Courtney K, Andrés V, Featherstone RM. A new and rapid colorimetric determination of acetylcholinesterase activity. Biochem Pharmacol. 1961;7:88–95.

25. Ajiboye B, Ojo OA, Akuboh O, Okesola MA, Idowu OT, Oyinloye B, et al. The Protective Effect of Polyphenol-Rich Extract of Syzygium cumini Leaves on Cholinesterase and Brain Antioxidant Status in Alloxan-Induced Diabetic Rats. Jordan J Bio Sci. 2018; 11: 163-169.

26. latha Alikatte K, Akondi BR, Yerragunta VG, Veerareddy PR, Palle S. Antiamnesic activity of Syzygium cumini against scopolamine induced spatial memory impairments in rats. Brain Dev. 2012;34:844–51.

27. Lakshmana M, Rao BS, Dhingra NK, Ravikumar R, Raju T. Chronic J_) deprenyl administration increases dendritic arborization in CA3 neurons of hippocampus and AChE activity in specific regions of the primate brain. Brain Res. 1998;796:38–44.

28. Rao SB, Chetana M, Devi PU. Centella asiatica treatment during postnatal period enhances learning and memory in mice. Physiol Behav. 2005;86:449–57.

29. Layer P, Weikert T, Alber R. Cholinesterases regulate neurite growth of chick nerve cells in vitro by means of a non-enzymatic mechanism. Cell Tissue Res. 2004;273:219–26.

30. Nawaz A, Batool Z, Shazad S, Rafiq S, Afzal A, Haider S. Physical enrichment enhances memory function by regulating stress hormone and brain acetylcholinesterase activity in rats exposed to restraint stress. Life Sci. 2018;207:4R_49.

31. Coutinho AE, Chapman K. The anti-inflammatory and immunosuppressive effects of glucocorticoids, recent developments and mechanistic insights. Mol Cell Endocrinol. 2011;335:2–13.

32. Dutra RC. In vitro Assessment of Anti-aging Properties of Syzygium cumini (l.) Leaves Extract. Biomed J Sci Tech Res. 2019;13(4):10185–91.

33. Belapurkar P, Goyal P. In vitro evaluation of phytochemical and antioxidant properties of Syzygium cumini leaves and their synergistic

effect on its antimicrobial property. Int J Res Pharm Sci. 2014;5:254–8.

34. Choi CW, Kim SC, Hwang SS, Choi BK, Ahn HJ, Lee M, et al. Antioxidant activity and free radical scavenging capacity between Korean medicinal plants and flavonoids by assay-guided comparison. Plant Sci. 2002;163:1161–8.

35. Soares J, Rosa A, Motta P, Cibin F, Roehrs R, Denardin ELG. Protective role of Syzygium cumini leaf extracts against paraquat-induced oxidative stress in superoxide-dismutase-deficient Saccharomyces cerevisiae strains. Acta Sci Biol Sci. 2019;41.

36. Mohamed A, Ali SI, El-Baz F. Antioxidant and Antibacterial Activities of Crude Extracts and Essential Oils of Syzygium cumini Leaves. PLoS One. 2013;8.

37. Bhati GS, Vaidya X, Sharma P, Agnihotri A. Evaluation Of Phytochemicals And Free Radical Scavenging Behavior In Different Parts Of Syzygium Cumini. Int J Curr Pharm Res. 2017;9:180–5.

38. Rahaman A, Hossain S, Rahman M, Hossain I, Nahar T, Uddin B, et al. Syzygium Cumini (L.) Seed Extract Improves Memory Related Learning Ability of Old Rats in Eight Arm Radial Maze. J Pharmacogn Phytochem. 2013;1:85–94.

39. Ohkawa H, Ohishi N, Yagi K. Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. Anal Biochem. 1979;95 2:351–8.

40. Rekha N, Balaji R, Deecaraman M. Effect of aqueous extract of Syzygium cumini Pulp on antioxidant defense system in streptozotocin induced diabetic rats. Iran J Pharmacol Ther. 2008;7:137–45.

41. Kabuto H, Tada M, Kohno M. Eugenol [2-methoxy-4-(2-propenyl)phenol] prevents 6-hydroxydopamine-induced dopamine depression and lipid peroxidation inductivity in mouse striatum. Biol Pharm Bull. 2007;30 3:423–7.