Open Access
Check for updates
International Journal of Medical Science and Dental Health (ISSN: 2454-4191)
Volume 11, Issue 12, December 2025
Doi: https://doi.org/10.55640/ijmsdh-11-12-09

# Effects of Amygdalus scoparia Gum on Passive Avoidance Learning and Cortisol Levels in Male Wistar Rat

**Hasnain Mohammed Hassan**
Assistant Lecturer - Karbala Governorate Education Directorate - Biology - Animal Physiology - Karbala - Iraq

**Received:** 28 October 2025, **accepted:** 30 November 2025, **Published Date:** 22 December 2025

## Abstract

**Introduction**: *Amygdalus scoparia* gum is a polysaccharide secreted from the wild almond tree. this gum is traditionally used as an emulsifying agent alongside tragacanth and gum arabic. Historically, it has been prescribed as a medicinal plant for enhancing memory.

**Methods**: In this experimental study, 32 adults male Wistar rats were used. After weighing, the animals were divided into 4 groups of 8: **Control** group; They did not receive any medication and all the conditions of this group were similar to the other 3 groups. **Sham** group; The animals in this group were injected with distilled water intraperitoneally. **Experimental** groups; Which received the extract at a dose of 20 mg/kg and 40 mg/kg intraperitoneally for 15 days, respectively. Zodu gum extract was prepared from the wild almond trees of the Arsanjan region without any additives. Using the shuttle box device, the effect of the extract of the gum of the mountain almond plant on passive avoidance learning and measuring the plasma level of the hormone cortisol was evaluated.

**Results**: The effect of doses of 20 and 40 mg/kg of the gum of the mountain almond plant on the hormone cortisol and the level of passive avoidance learning (STL) was examined, and a significant difference was observed between the experimental and control groups ($p < 0.001$). Also, this extract increased the recall time in the shuttle box test and increased the level of the hormone cortisol ($p < 0.01$). The dose of 40 mg/kg was selected as the effective dose.

**Conclusion**: Passive avoidance learning and the level of the hormone cortisol as an indicator of the level of learning are directly related to the consumption of the gum of the *Amygdalus scoparia* plant (Zodu), and the gum extract of this plant enhances memory and increases the learning process.

**Keywords:** Passive avoidance learning, Zodu (*Amygdalus scoparia*) gum, male Wistar rat, cortisol

## 1- Introduction

Zodu or Ezdu gum (*Amygdalus scoparia*) is a polysaccharide secreted from the wild almond tree. According to research findings on this natural and indigenous gum, Zodu gum can be utilized in industry as a thickener, emulsifier, and stabilizer. This species is widely distributed across Iran, with its geographical spread reported in the provinces of Fars, Chaharmahal and Bakhtiari, Yazd, Kerman, Khorasan, Tehran, Kurdistan, Lorestan, Kermanshah, Arak, Ilam, Sistan and Baluchestan, Hormozgan, Bushehr, and Khuzestan (Fig1). Zodu gum occurs in various colors, ranging from white and light yellow to orange and red (1).

[1] Step through latency

**Fig1**: Morphology of the Scots Almond Plant (*Amygdalus scoparia*)

Zodu gum (Fig2) is a non-starch hydrocolloid with the nature of an acidic polysaccharide, the majority of which consists of the sugar unit galactose with a smaller amount of arabinose. This substance is used as fuel for the brain, cells and red blood cells, and the body uses it to produce energy. Zodu gum or mountain almond contains alkaloids, tannins and polyphenol compounds. (2)

**Fig2**: *Amygdalus scoparia* gum

Flavonoids represent the most abundant category of polyphenolic substances found in plants, present widely in fruits, vegetables, and cereals (3). Research has indicated an inverse relationship between the intake of these compounds and mortality linked to cardiovascular diseases as well as cognitive decline associated with aging. In the realm of traditional medicine, acacia gum has been recognized as a natural remedy endowed with

medicinal qualities, commonly employed to address various health conditions owing to its anti-inflammatory, antiseptic, and reparative effects (4).

Polyphenols act in multiple ways, enhancing memory and learning through several overlapping mechanisms: reducing oxidative stress and neuroinflammation, improving mitochondrial metabolism, and protecting the blood-brain barrier, which prevents neuronal damage. These indirect effects are consistent with increased neurotrophic signaling (e.g., increased BDNF and activation of the CREB pathway) and enhanced synaptic plasticity; thus, the ability to record and retain memory is enhanced (5). Some evidence suggests that polyphenols can also modulate the HPA axis and stress markers (e.g., cortisol) and neurotransmitter switches, all of which contribute to better regulation of stress responses and memory (6). Considering the reviews of the literature on the physiological effects of Zodu gum on the mammalian nervous system, and particularly on areas affecting memory and learning, and considering the polyphenolic and antioxidant properties of this plant compound, there were not many and significant articles. Therefore, research on this issue seems to be important.

[1] Brain derived neurotrophic factor

[1] Cyclic- AMP response element binding

[1] Hypothalamic-pituitary axis

**2- Materials and Methods**

In this research, 32 adult male Wistar rats, each weighing between 180 and 220 grams and aged 2.5 to 3 months, were obtained from the Razi Pharmaceutical Company in Karaj. These rats were acclimated for one week in the animal facility of Shiraz Islamic Azad University under controlled environmental conditions, including a temperature of 21±2°C and a lighting cycle of 12 hours light and 12 hours dark. Between 9 and 11 am, the rats underwent adaptation, training, and memory recall phases using a shuttle box apparatus where their passive avoidance behavior was assessed and recorded. The memory evaluation method employed was based on passive avoidance learning, which involves the rat learning to avoid entering a dark compartment where it previously received a mild aversive stimulus. The test apparatus typically includes a lighted and a dark compartment separated by a door; the animal naturally prefers the dark side but learns to avoid it in response to negative reinforcement such as an electric foot shock. The study material was gum extract from the mountain almond (Amygdalus scoparia) trees sourced from the Arsanjan region, prepared without additives for use in the experiments.

The animals were generally divided into four groups, which are:

**Control** group; They were not given any medication, but all their maintenance and feeding conditions were the same as the other groups and they were placed in a shuttle box device. **Sham** group; this group was injected with distilled water intraperitoneally(IP). **Experimental group one**; rats that were injected with the extract at a dose of 20 mg/Kg intraperitoneally for 15 days. **Experimental group two**; rats that were injected with the extract at a dose of 40 mg/Kg intraperitoneally for 15 days (N=8).

` **Passive avoidance learning method**: It consists of three stages of habituation, training and recall. A**) Habituation** stage: First, in order to habituate, the animal is placed in the lighted part of the device and after 5 seconds, the guillotine door is opened. As soon as the animal enters the dark part, the guillotine door is closed and after 30 seconds, the guillotine door is opened again so that the animal goes to the lighted compartment. If the animal does not go to the lighted compartment, it is guided by hand and then the animal is removed from the device. This stage is repeated after 30 minutes. (Fig3)

**Fig3**: Overview of the shuttle box machine

b) **Training** stage: During the training phase, about 30 minutes after habituation, the animal's foot is first moistened with distilled water to enhance electrical conductivity. The rodent is then placed in the brightly lit chamber. After a 10-second delay, the guillotine door is raised to allow entry into the dark compartment. Once the animal fully enters the dark area, the door is slowly closed, and a mild electric foot shock of 1 mA, lasting 5 seconds at 50 Hz, is delivered to its paw. The animal is then observed until it exits the dark chamber, after which it is returned to its home cage briefly. The animal is subsequently placed back into the light chamber, and after another 10-second interval, the door is opened again. If the rodent refrains from entering the dark compartment for a maximum of 2 minutes, the training session concludes. Otherwise, the shock and entry cycle is repeated until the avoidance behavior is acquired.

c) **Recall** stage: To evaluate memory retention, 24 hours after the training session, the animal is placed once again in the illuminated chamber. Following a 10-second interval, the guillotine door is gradually opened, and the time taken by the animal to fully enter the dark compartment is recorded as the step-through latency (STL). The maximum allowable duration for the animal to enter the dark chamber is set at 600 seconds. This latency serves as a measure of memory recall, where a longer delay indicates better retention of the aversive experience associated with the dark area.

**Results**

**1- Study of the results of the effect of different doses of the extract on STL**

The mean and standard deviation of the variables STL1 and STL2 were examined between the control group and the sham group, and no significant difference was observed between these two groups ($p>0.05$). Due to the lack of significance, the control group was compared with the experimental groups.

**Table 1**: Comparison of mean and standard deviation of STL1 and STL2 between control group and sham group

| Variable | Control (Mean±SEM) | Sham (Mean±SEM) | p-value |
|---|---|---|---|
| STL1 | 38.87± 4.88 | 37.12±7.03 | 0.841 |
| STL 2 | 342.37±99.46 | 336.25±77.78 | 0.962 |

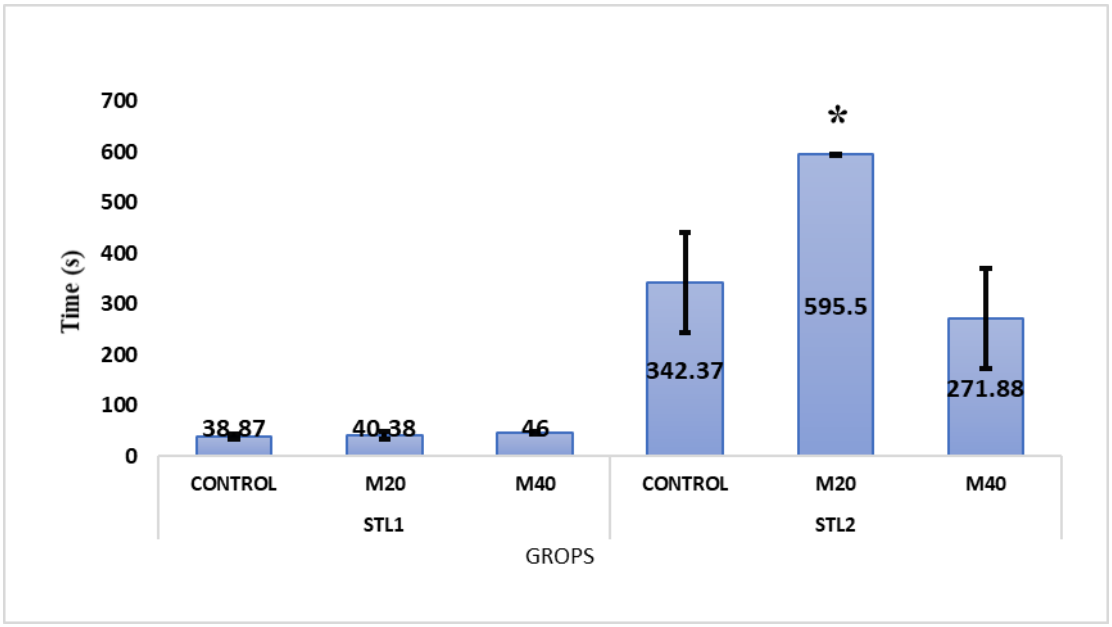


**Fig 4**: Mean and standard deviation of STL1 and STL2 between the control group and the experimental groups of 20 and 40 mg/kg of extract. This chart showed that there was no significant difference for STL1 between the control group and the experimental groups of 20 and 40 mg/kg at the 0.05 level. However, a significant increase was observed for STL2 between the control group and the experimental group of 20 mg/kg. The amount of STL2 in the experimental group of 40 mg/kg decreased in a way that did not show a significant difference with the control group. The * symbol indicates significance at the p≤0.05 level.

**2- Studying the results of the effect of different doses of the extract on serum cortisol levels**

The mean and standard deviation of the Cortisol variable were examined between the control group and the sham group, and a significant difference was observed between these two groups ($p<0.05$). Given the significant difference, the sham group was compared with the experimental groups.

**Table 2**: Comparison of mean and standard deviation of cortisol between the control group and the sham group

| Variable | Control (Mean±SEM) | Sham (Mean±SEM) | p-value |
|---|---|---|---|
| Cortisol(µg/dL) | 39.57 ± 1.98 | 48.93 ± 3.39 | 0.036 |

The effect of the extract at doses of 20 and 40 mg/kg by intraperitoneal injection on cortisol was examined with the sham group, and a significant difference was observed between the experimental and sham groups ($p<0.001$), and the dose of 40 mg/kg was selected as the effective dose.

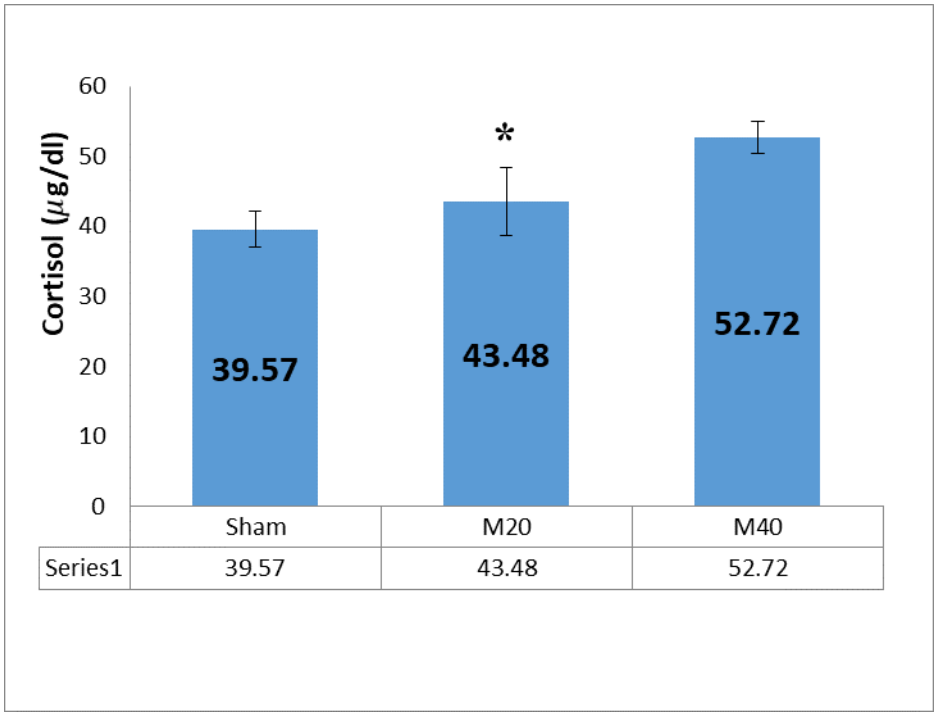


**Figure 5**: Mean and standard deviation of serum cortisol levels between the sham group and the experimental groups of 20 and 40 mg/kg of extract. This figure shows that the mean serum cortisol levels between the sham group and the experimental group of 20 mg/kg were significantly different at the 0.001 level. And also between the sham group and the experimental group of 40 mg/kg there was a significant difference at the 0.001 level. The result is that the mean of the experimental group with a dosage of 20 and 40 mg/kg show a significant increase compared to the control group. The * symbol indicates significance at the p≤0.001 level.

**Discussion**

Neurological conditions such as amnesia, diminished attention spans, and Alzheimer's disease pose significant treatment challenges, as current therapeutic options often lack efficacy and frequently cause adverse effects. Pharmaceuticals designed to enhance memory, like piracetam, tacrine, and metrifonate, tend to provide limited benefit and are associated with side effects. Recently, scientific interest has grown in the neuroprotective abilities of plants within the Rosaceae family, particularly species of Amygdalus (almonds), which are abundant in bioactive phenolic and flavonoid compounds. These compounds exhibit potent antioxidant and anti-inflammatory effects, which may support neuronal health by modulating oxidative stress and regulating cholinergic neurotransmission, thereby potentially improving cognitive functions such as learning and memory (7).

Previous studies have shown that almond extract (*Prunus amygdalus*) reversed scopolamine-induced amnesia in mice by inhibiting acetylcholinesterase and improving performance in avoidance and maze tests (8). Similar results were obtained in the present study using Amygdalus scoparia gum extract, indicating that both species have similar bioactive compounds. Also, Saheeb et al. (2014) confirmed the anxiolytic activity of almond extract in animal models (9) and Dhawan et al. (2017) showed that almond extract has a protective effect against aluminum chloride-induced neurochemical changes and restores spatial memory (10).

Studies with Sajjadi and his coworkers conducted in Iran also indicate that almond root extract improves learning and memory in mice treated with scopolamine, which is achieved through the inhibition of acetylcholinesterase and butyrylcholinesterase enzymes (11). These findings are consistent with the results of alami et al. (2010), who showed that almond consumption improves cognitive function by modulating cholinergic activity and lipid metabolism (12). Also, Hammoudi et al. (2016) reported that the methanol extract of A. scoparia has potent antioxidant and anti-acetylcholinesterase activity (13).

More recent evidence also indicates the antioxidant and anti-aging effects of almonds. Batool et al. (2018) showed that almond consumption improves oxidative stress and reduces memory impairment in mice treated with scopolamine (14). Rakic et al. (2022) reported

improvements in working and visuospatial memory in older adults with a daily intake of three ounces of almonds (15). Bahaaeddin et al. (2023) also showed that maternal almond consumption improved memory and stress adaptation in infants by increasing CREB and BDNF expression (16).

Nuts such as almonds, hazelnuts, and walnuts provide macronutrients, micronutrients, and phytochemicals that affect various pathways associated with Alzheimer's disease, including amyloidogenesis, tau phosphorylation, oxidative stress, and neurogenesis (17). Similarly, Coates et al. (2020) showed that long-term almond consumption improved markers of cardiometabolic health and indirectly enhanced cognitive function (18).

Overall, the results of the present study are consistent with previous findings and show that Amygdalus scoparia gum extract improves learning and memory through its polyphenolic compounds and by enhancing the antioxidant system, cholinergic activity, and neural plasticity.

**References**

1. Khalesi, H., Alizadeh, M., & Bari, M. R. (2012). Physicochemical and functional properties of Zedo gum exudating from Amygdalus scoparia spach trees in the Miyan Jangal area of the Fars Province.
2. Seyfi, R., Kasaai, M. R., & Chaichi, M. J. (2019). Isolation and structural characterization of a polysaccharide derived from a local gum: Zedo (Amygdalus scoparia Spach). *Food hydrocolloids*, *87*, 915-924.
3. Yonekura-Sakakibara, K., Higashi, Y., & Nakabayashi, R.. The origin and evolution of plant flavonoid metabolism. *Frontiers in plant science*,2019, *10*, 468057.
4. Shirzadi, I., Yavari, A., & Hadadinejad, M. (2023). Evaluation of Morphological Diversity of Different Ecotypes of Amygdalus scoparia Spach: A Medicinal Plant Resistant to Hard Environmental Conditions. *Journal of Medicinal plants and By-product*, *12*(2), 125-133.
5. Naomi, R., Yazid, M. D., Teoh, S. H., Balan, S. S., Shariff, H., Kumar, J., Bahari, H., & Embong, H. (2023). *Dietary polyphenols as a protection against cognitive decline: Evidence from animal experiments; mechanisms and limitations.* Antioxidants, 12(5), 1054.
6. Hunt, T., Pontifex, M. G., & Vauzour, D. (2024). *(Poly)phenols and brain health – beyond their antioxidant capacity.* FEBS Letters, 598(24), 2949–2962.
7. Haider, S., Batool, Z., & Haleem, D. J. (2012). Efectos nootrόficos e hipofϑgicos del consumo prolongado de almendras (Prunus amygdalus) en ratas. *Nutrici*ό*n Hospitalaria*, *27*(6), 2109-2115.
8. Kulkarni, K. S., Kasture, S. B., & Mengi, S. A. (2010). Efficacy study of Prunus amygdalus (almond) nuts in scopolamine-induced amnesia in rats. *Indian journal of pharmacology*, *42*(3), 168-173.
9. Sahib, Z. H. (2014). Assessment of anxiolytic activity of nuts of Prunus amygdalus Dulcis (almond) in mice. *Medical Journal of Babylon*, *11*(4), 817-824.
10. Dhawan, R. K. (2017). Evaluation of the protective effect of Prunus amagdylus against aluminium chloride induced neurochemical alterations and spatial memory deficits in rats. *International Journal of Basic & Clinical Pharmacology*, *6*(12), 2881.
11. Sajjadi, M., Oskoueian, E., Karimi, E., & Ebrahimi, M. (2021). Amygdalus spinosissima root extract enhanced scopolamine-induced learning and memory impairment in mice. *Metabolic Brain Disease*, *36*(7), 1859-1869.
12. Alami, K., Nazari, Z., Bayat, R., Bayat, A., Qasemi, S., Karimi, F., ... & Mousavi, S. Y. (2024). Cognitive Effects of Almond Consumption: A Review of Animal Studies. *Nutrition and Dietary Supplements*, 105-128.
13. HAMMOUDI, R., CHEBROUK, F., Benameur-Saggou, H., Belkhalfa, H., Mahammed, M. H., Saher, L., ... & Haffas, M. (2024). Chemical composition, insecticidal and acetylcholinesterase inhibitory activities against Parlatoria blanchardi Targ of essential oils from Deverra scoparia Coss. & Dur. dried with different methods.
14. Batool, Z., Tabassum, S., Siddiqui, R. A., & Haider, S. (2018). Dietary supplementation of almond prevents oxidative stress by advocating antioxidants and attenuates impaired aversive memory in male rats. *Plant foods for human nutrition*, *73*(1), 7-12.
15. M. Rakic, J., Tanprasertsuk, J., Scott, T. M., Rasmussen, H. M., Mohn, E. S., Chen, C. Y. O., & Johnson, E. J. (2022). Effects of daily almond consumption for six months on cognitive measures

in healthy middle-aged to older adults: a randomized control trial. *Nutritional Neuroscience*, *25*(7), 1466-1476.

**16.** Bahaeddin, Z., Khodagholi, F., Foolad, F., Emadi, F., Alijaniha, F., Zareh Shahamati, S., ... & Naseri, M. (2023). Almond intake during pregnancy in rats improved the cognitive performance of adult male offspring. *Nutritional Neuroscience*, *26*(9), 888-900.

**17.** Vaishnavi, G., & Justin Thenmozhi, A. (2023). Nuts and their potential role in Alzheimer's disease. In *Nutraceuticals for Alzheimer's Disease: A Promising Therapeutic Approach* (pp. 125-149). Singapore: Springer Nature Singapore.

**18.** Coates, A. M., Morgillo, S., Yandell, C., Scholey, A., Buckley, J. D., Dyer, K. A., & Hill, A. M. (2020). Effect of a 12-week almond-enriched diet on biomarkers of cognitive performance, mood, and cardiometabolic health in older overweight adults. *Nutrients*, *12*(4), 1180.