PANAX GINSENG AS A CANDIDATE FOR IMPROVING COGNITIVE FUNCTION : A SYNTHESIS OF PRECLINICAL AND CLINICAL EVIDENCE

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ABSTRACT

Background: *Cognitive function* encompasses memory, attention, information processing speed, and executive function, which play a crucial role in learning, work, and quality of life. *Panax ginseng* C.A. Meyer contains ginsenosides and other bioactive components that have been extensively studied for their potential to support neural function through antioxidant and anti-inflammatory effects, neurotransmitter modulation, and enhanced synaptic plasticity. **Objective**: This article aims to synthesize preclinical and clinical evidence regarding the potential of *Panax ginseng* as a candidate for enhancing cognitive function and to assess the appropriateness of the study populations, the strength of the evidence, and the main limitations of the analyzed articles. A narrative literature review was conducted through searches of PubMed, Scopus, ScienceDirect, and Google Scholar. Keywords used included "*Panax ginseng*," "Korean red ginseng," "ginsenoside," "cognitive function," "memory," "attention," "executive function," "neuroprotection," "subjective memory impairment," "mild cognitive impairment," "Alzheimer's disease," and "adolescent." Priority was given to publications from 2019 to 2025, with limited exceptions for highly relevant clinical studies, particularly those involving adolescent populations or controlled clinical trial designs. Articles were selected based on predetermined inclusion and exclusion criteria. Data were extracted regarding authors, year, design, population, intervention, duration, outcomes, primary results, strength of evidence, and limitations. **Results**: Clinical evidence suggests that some *Panax ginseng* preparations may improve indicators of memory, general cognitive function, stress, and cognitive task performance in adults or individuals with mild memory impairment. Evidence in adolescents remains limited and primarily stems from a single small clinical trial. Mechanistic studies support the potential of ginsenosides through reduction of oxidative stress, inhibition of inflammation, protection against apoptosis, enhancement of synaptic plasticity, and influence of gut microbiota metabolism on ginsenoside bioavailability. **Conclusion**: *Panax ginseng* has the potential as a nutraceutical candidate for supporting cognitive function, but claims of benefits must be tailored to the specific populations studied. The strongest evidence currently comes primarily from adult and elderly populations or subjects with memory impairment, whereas direct evidence in adolescents remains insufficient.

Keywords: Panax ginseng; ginsenosides; cognitive function

INTRODUCTION

Cognitive functions refer to a set of mental abilities involved in receiving, processing, storing, and using information. These abilities include attention, memory, learning, problem-solving, and decision-making. In daily life, cognitive functions play a vital role, particularly in supporting educational success, work productivity, and the quality of social interactions. If these functions are impaired or diminished, a person may have difficulty understanding information, maintaining concentration, recalling experiences, and performing activities optimally.

In recent years, the use of natural ingredients to support brain health has garnered increasing attention. This is linked to the public's growing demand for promotive approaches that are easily accepted, relatively safe, and have the potential to be developed into functional foods or nutraceuticals. One medicinal plant that has been extensively studied is Panax ginseng C.A. Meyer. This plant is known to contain various bioactive compounds, particularly ginsenoside- s, which play a role in its various biological activities. Variations in the saponin content of Panax ginseng are one of the factors causing the plant's pharmacological effects to differ, depending on the type of extract, the composition of active compounds, the processing method, and the dosage used (Piao et al., 2020).

From a biological mechanism perspective, ginsenosides are known to be associated with several pathways involved in maintaining cognitive function. Feng et al. (2022) explain that ginsenosides have the potential to influence disruptions in the cholinergic system, oxidative stress, apoptosis, inflammation, synaptic plasticity, and neurogenesis. These pathways are closely related to learning ability, memory formation, and the protection of nerve cells against damage. Therefore, the mechanism of action of Panax ginseng is not limited to a single pathway but involves interrelated biological processes that support brain

health.

Based on the above discussion, this article aims to review and synthesize preclinical and clinical evidence regarding the potential of Panax ginseng as a candidate for supporting cognitive function. In addition, this article also analyzes the strength of the evidence, key limitations, and the mechanistic aspects underlying the effects of Panax ginseng on cognitive function.

RESEARCH METHODS

This article was structured using a narrative literature review design with a descriptive synthesis approach. The narrative design was chosen because the available articles exhibited significant diversity in terms of study design, population characteristics, types of Panax ginseng preparations, dosage, duration of intervention, and cognitive measurement instruments. Thus, the primary objective of this study is not to calculate the magnitude of the effect statistically, but rather to map the evidence, assess the consistency of findings, and identify research limitations relevant to the development of future studies.

Literature Search Strategy

The literature search was conducted using the PubMed, Scopus, ScienceDirect, and Google Scholar databases. The search focused on English- and Indonesian-language literature using a combination of keywords related to the material, active components, cognitive outcomes, and population characteristics. The main keywords used were “Panax ginseng,” “Korean red ginseng,” “red ginseng,” “ginseng sprout extract,” “ginsenoside,” “ginsenoside Rg1,” “gintonin,” “cognitive function,” “memory,” “attention,” “executive function,” “working memory,” “learning,” “neuroprotection,” “subjective memory impairment,” “mild cognitive impairment,” “Alzheimer’s disease,” “adolescent,” and “teenager.”

These keywords were used individually or in combination with the Boolean operators AND and OR. The initial search focused on publications from 2019 to 2025. However, studies published before 2020 were still considered on a limited basis if they met one of two criteria: (1) the study was a clinical trial frequently cited as a primary reference in recent articles; or (2) the study directly involved an adolescent population, as direct evidence for this age group is very limited.

Inclusion and Exclusion Criteria

The inclusion criteria for this review are as follows: (1) articles discussing Panax ginseng or its active compounds, particularly ginsenosides, in relation to cognitive function; (2) articles reporting on cognitive outcomes such as memory, attention, learning ability, executive function, general cognitive performance, or neuroprotective mechanisms related to cognition; (3) articles in the form of preclinical studies, clinical trials, randomized controlled trials, systematic reviews, or meta-analyses relevant to the research topic; (4) articles published in peer-reviewed scientific journals between 2020 and 2025; (5) articles in English or Indonesian; and (6) articles available in full text.

The exclusion criteria for this study include: (1) duplicate articles; (2) articles that do not specifically discuss Panax ginseng or ginsenosides; (3) articles that discuss only other herbal plants without a separate analysis of Panax ginseng; (4) articles that do not evaluate cognitive function or mechanisms related to cognition; (5) articles published outside the 2019–2025 timeframe, except as supporting literature; (6) articles for which the full text is unavailable; and (7) editorials, letters to the editor, opinion pieces, popular reports, and conference abstracts that do not contain complete research data.

Article Selection Process

Article selection is conducted in four stages. The first stage involves identifying articles using keywords across four databases. The second stage involves removing duplicate articles based on title, author name, year, and DOI. The third stage involves screening titles and abstracts to assess relevance to Panax ginseng and cognitive outcomes. The fourth stage involves reviewing the full text to ensure the appropriateness of the study design, population, intervention, and outcomes, as well as the relevance of the article to the study’s objectives.

Data from the selected articles were extracted based on author name and year of publication, study design, study population or model, type of intervention, duration of intervention, measured outcomes, primary outcomes, strength of evidence, and major limitations. The assessment of the strength of evidence was conducted descriptively based on study design and the relevance of the findings to cognitive function. Randomized controlled trials and meta-analyses were categorized as strong evidence if they had a controlled design and clearly defined cognitive outcomes. Preclinical studies were categorized as supporting evidence because they provided mechanistic explanations but could not yet be directly generalized to humans. Review articles were used as supporting evidence to strengthen the understanding of mechanisms of action and the consistency of findings across various studies.

The extracted data were then analyzed narratively by comparing the similarities and differences among the articles. The analysis focused on the potential of Panax ginseng to support cognitive function, the biological mechanisms underlying these effects, the strength of evidence from each study, and the limitations of the research that still need to be considered. In addition, this review also highlights the lack of direct evidence in adolescent populations, so the use of Panax ginseng in this age group should be interpreted with caution and requires further clinical research.

RESULTS

The results of the study show that the articles analyzed consisted of controlled clinical trials, systematic reviews, meta-analyses, and mechanistic and pharmacokinetic review articles. Clinical studies provide insights into the effects of Panax ginseng in humans, while mechanistic and pharmacokinetic articles help explain the possible biological pathways and factors that influence the bioavailability of ginsenosides. A summary of the characteristics, main results, strength of evidence, and limitations of the analyzed articles is presented in Table 1.

Table 1. Summary of Key Articles Analyzed

No	Author	Study Design	Population / Model	Intervention & Duration	Outcome Measured	Main Result	Strength of Evidence	Main Limitations
1	Takae et al. (2019)	Randomized, double-blinded, placebo-controlled parallel trial	40 teenagers aged 13–18	Tea containing Panax ginseng; 4 weeks	BVRT, UKT, and TK: The Tanaka AB-Style Intelligence Test System	There was a significant interaction effect on BVRT scores; the results suggest an improvement in visual cognitive performance.	Moderate; direct evidence from a healthy, young population using a placebo control.	Small sample size, short duration, publications prior to 2020, and findings limited to certain aspects of visual cognition.
2	Baek et al. (2024)	RCT, double-blind, placebo-controlled	80 subjects aged 55–75 with subjective memory impairment	ThinkGIN™ 450 mg/day; 12 weeks	SVLT, RCFT, MoCA-K, PSQI-K, AChE, and safety	Verbal memory, visual memory, general cognitive function, sleep quality, and AChE levels improved compared to placebo; no serious safety issues were observed.	High among the elderly SMI population; generalizability is limited to healthy populations and different age groups.	A population of older adults with SMI, not adolescents; a single-center study; duration of only 12 weeks.

3	Dorma l et al. (2025)	Randomized, double-blind, placebo-controlled study	149 adults with moderate stress levels	Hydroponically grown Red Panax ginseng, 200 mg/day, contains 24 mg of ginsenosides; 3 weeks	PSS, BDI, PANAS, and CANTAB subtests	There was a decrease in perceived stress and negative affect, as well as a faster response time on the spatial planning task.	Moderate to high; RCT design and a relatively larger sample size.	The duration was very short; the adult population experienced moderate stress; cognitive effects were more evident in response latency than in all cognitive domains.
4	Park et al. (2019)	Randomized, double-blind, placebo-controlled clinical trial	90 Korean volunteers with mild cognitive impairment	Panax ginseng powder 3 g/day; 24 weeks	K-MMSE, K-IADL, SNSB, RCFT	Significant improvements in RCFT immediate recall and delayed recall compared to placebo; no serious adverse events.	Moderate to high for MCI; generalizability is limited to different age groups and clinical conditions	The population was limited to individuals with MCI; a single-center study; some outcomes showed no significant differences; a single-center study; some outcomes showed no significant differences.
5	Lee et al. (2024)	Review of clinical and mechanistic articles	Studies on SMI, MCI, and early-stage Alzheimer's disease dementia	Ginseng components, including ginsenosides and gintonin; duration varies	Clinical cognition, working memory, and biological mechanisms	Ginseng and its components may support cognitive function in SMI, MCI, and early-stage AD dementia, but the primary	In progress; summarizing the latest clinical and mechanistic evidence.	Not a meta-analysis; the study population consists primarily of adults and older adults; heterogeneity in

						component most responsible for these effects remains unclear.		interventions and outcomes.
6	Kim et al. (2025)	Systematic review and meta-analysis RCT	Individuals with cognitive or memory impairment, including SMI, MCI, and Alzheimer's disease	Ginseng in various forms and doses; duration varies	MMSE and ADAS-Cog	Ginseng has been associated with improvements in several cognitive measures, including higher MMSE scores and lower ADAS-Cog scores.	High as secondary evidence; however, it depends on the quality of the primary studies.	The heterogeneity of the studies, variations in dosage, and differences in clinical populations, as well as the lack of sufficient data on the effects in the general healthy population.
7	Feng et al. (2022)	A mechanistic review of ginsenosides and cognitive impairment	Preclinical models and mechanistic evidence related to cognitive impairment	Various ginsenosides, including Rg1, Rb1, and other components; duration varies	Cholinergic dysfunction, oxidative stress, apoptosis, inflammation, synaptic plasticity, neurogenesis	Ginsenosides have the potential to improve cognitive impairment through regulation of the cholinergic system, as well as through their antioxidant, anti-inflammatory, and anti-apoptotic effects, and by enhancing neural plasticity.	Low to moderate for clinical claims; strong as a mechanistic basis.	Most of the evidence does not come from human clinical trials; the extrapolation of doses from preclinical models to humans remains limited.
8	Yang	A Review of	A Study of	Ginsenosides	Metabolism,	The	Low to	Does not

	et al. (2020)	Pharmacokinetics and Gut Microbiota Metabolism	the Metabolism of Ginsenosides and Their Metabolites	are metabolized by the gut microbiota into active metabolites; the duration varies	bioactivity, and factors affecting bioavailability	gastrointestinal microbiota plays a key role in producing ginsenoside metabolites that can affect bioactivity.	moderate for direct cognition; important for interpreting bioavailability.	focus directly on cognitive outcomes; the relationship with cognitive clinical effects still needs to be further tested.

DISCUSSION

The Potential of Panax ginseng as a Candidate for Cognitive Function Enhancement

Based on the analyzed research findings, Panax ginseng shows potential as a candidate for enhancing cognitive function through various outcomes, such as memory, attention, executive function, learning ability, and general cognitive performance. The findings in the results table show that the effects of Panax ginseng are supported not only by clinical studies in humans but also by mechanistic studies and pharmacokinetic reviews that elucidate its potential biological pathways. However, the strength of evidence from each study varies due to differences in study design, study population or model, type of intervention, duration of administration, and the cognitive assessment tools used (Takae et al., 2019; Baek et al., 2024; Feng et al., 2022).

In general, research findings indicate that the benefits of Panax ginseng are most frequently reported in the domains of memory and general cognitive performance. This is evident in the studies by Baek et al. (2024), Park et al. (2019), and the systematic review by Kim et al. (2025), which demonstrate improvements in several cognitive indicators following ginseng administration. However, these effects are not yet entirely consistent across all cognitive outcomes; therefore, Panax ginseng is more appropriately positioned as a potential candidate that still requires further evidence through additional research (Park et al., 2019; Baek et al., 2024; Kim et al., 2025).

Clinical Evidence on Memory and Cognitive Function

The results of a study by Baek et al. (2024) show that administering 450 mg/day of ThinkGIN™ for 12 weeks to 80 subjects aged 55–75 years with subjective memory impairment led to improvements in verbal memory, visual memory, general cognitive function, sleep quality, and acetylcholinesterase activity. This study has a high level of evidence because it employed a randomized, controlled, double-blind, placebo-controlled trial design. These findings suggest that Panax ginseng has clinical potential in supporting memory function, particularly in individuals with subjective memory complaints (Baek et al., 2024).

Consistent results were also found in a study by Park et al. (2019), which reported that administering 3 g/day of Panax ginseng powder for 24 weeks to 90 Korean volunteers with mild cognitive impairment resulted in significant improvements in immediate recall and delayed recall. These findings support the hypothesis that memory is one of the cognitive domains that responds well to Panax ginseng intervention. However, the study also has limitations because some cognitive outcomes did not show significant differences, so the effects of ginseng cannot be considered equally strong across all cognitive aspects (Park et al., 2019).

In addition, a study by Takae et al. (2019) showed that consuming tea containing Panax ginseng for four weeks had an effect on BVRT scores related to visual cognitive performance. These findings support the notion that Panax ginseng can influence certain aspects of cognitive function. However, the strength of the evidence from this study is still considered moderate due to the relatively small sample size, the short duration of the intervention, and the fact that the assessed outcomes were limited to visual cognitive aspects (Takae et al., 2019).

The Effects of Panax ginseng on Stress and Executive Function

In addition to memory, research findings also indicate that Panax ginseng may influence psychological aspects and executive function. A study by Dormal et al. (2025) reported that administration of 200 mg/day of hydroponically grown red Panax ginseng for

three weeks to 149 adults with moderate stress levels was associated with a reduction in perceived stress and negative affect, as well as faster responses on spatial planning tasks. These findings suggest that Panax ginseng may play a role not only in memory but also in stress regulation and planning ability (Dormal et al., 2025).

Although these results support the potential of Panax ginseng to enhance executive function, the limitations of the study by Dormal et al. (2025) should be noted. The intervention duration of only three weeks is relatively short to assess comprehensive changes in cognitive function. Furthermore, cognitive effects were more evident in response latency, whereas not all cognitive domains showed significant changes. Therefore, the results of this study indicate that the effects of Panax ginseng on executive function still require further investigation with a longer intervention duration and a broader range of cognitive measures (Dormal et al., 2025).

Synthesis of Evidence from Reviews and Meta-Analyses

The findings of the review by Lee et al. (2024) indicate that ginseng and its components, including ginsenosides and gintonin, have the potential to support cognitive function in conditions such as subjective memory impairment, mild cognitive impairment, and early Alzheimer's disease. This review reinforces the findings of clinical studies by summarizing the latest human and mechanistic evidence. However, as a review article, the strength of its evidence depends heavily on the quality of the primary studies analyzed and is still influenced by heterogeneity in interventions, populations, and study outcomes (Lee et al., 2024).

The meta-analysis by Kim et al. (2025) also supports ginseng's potential benefits for cognitive function. In that study, ginseng use in individuals with cognitive or memory impairment was associated with improvements in several cognitive indicators, including higher MMSE scores and lower ADAS-Cog scores. Since the meta-analysis synthesizes several randomized controlled trials, these results carry weight as secondary evidence. However, variations in dosage, dosage form, duration of intervention, and population characteristics remain limitations that need to be considered (Kim et al., 2025).

Based on the results of these reviews and meta-analyses, it can be concluded that Panax ginseng shows strong potential as a candidate for supporting cognitive function, particularly in populations with memory impairment or cognitive decline. However, the heterogeneity among studies indicates that the benefits of Panax ginseng cannot yet be conclusively determined for all population groups and all cognitive domains (Lee et al., 2024; Kim et al., 2025).

Biological Mechanisms Underlying Cognitive Effects

From a biological mechanisms perspective, Feng et al. (2022) explain that ginsenosides play a role in several pathways related to cognitive function, such as cholinergic dysfunction, oxidative stress, apoptosis, inflammation, synaptic plasticity, and neurogenesis. These pathways are closely linked to learning, memory formation, and the protection of neurons from damage. Therefore, these mechanistic findings support clinical evidence showing improvements in memory and cognitive function following the administration of Panax ginseng (Feng et al., 2022).

Ginsenosides play an important role in the cholinergic system because this system is involved in learning and memory processes. In addition, the antioxidant and anti-inflammatory activities of ginsenosides may help protect neurons from damage caused by oxidative stress and inflammation. This mechanism may explain why several clinical studies have found improvements in verbal memory, visual memory, and general cognitive function following administration of Panax ginseng (Baek et al., 2024; Feng et al., 2022).

In addition, ginsenosides have also been reported to be associated with synaptic plasticity and neurogenesis. Synaptic plasticity plays a role in the brain's ability to adapt to new information, while neurogenesis is associated with the formation of new nerve cells. Both of these processes support learning and memory functions, thus providing a relevant biological basis for explaining the effects of Panax ginseng on cognitive function (Feng et al., 2022).

Bioavailability and Variability in Response to Ginsenosides

The effectiveness of Panax ginseng is determined not only by its ginsenoside content but also by the bioavailability and metabolism of these active compounds in the body. Yang et al. (2020) explain that ginsenosides can be metabolized by the gut microbiota into active metabolites, including compound K. This metabolic process is important because these active metabolites play a role in determining the bioactivity of ginsenosides and the biological effects that occur after consumption of Panax ginseng (Yang et al., 2020).

Variations in gut microbiota among individuals may lead to differences in

response to Panax ginseng consumption. This may be one reason why results across studies are not always consistent. In addition to microbiota factors, variations in extract type, processing methods, dosage, dosage form, and duration of administration can also affect the levels of active compounds available in the body. Thus, pharmacokinetic and bioavailability aspects need to be considered in future Panax ginseng research (Yang et al., 2020).

Strengths and Limitations of the Evidence

The main strength of the analyzed research findings is the combination of clinical evidence, mechanistic reviews, and meta-analyses. Clinical studies such as those by Baek et al. (2024), Park et al. (2019), and Dormal et al. (2025) provide insights into the effects of Panax ginseng in humans. Meanwhile, the mechanistic review by Feng et al. (2022) explains the biological basis of ginsenoside effects on cognitive function. On the other hand, the meta-analysis by Kim et al. (2025) provides supporting secondary evidence by synthesizing the results of several randomized controlled trials (Baek et al., 2024; Dormal et al., 2025; Feng et al., 2022; Kim et al., 2025).

However, several limitations should be noted. First, the study populations vary widely, ranging from healthy individuals and those with moderate stress to subjects with memory impairment or cognitive decline. Second, the types of interventions used differ, such as tea containing Panax ginseng, ThinkGIN™, Panax ginseng powder, hydroponically grown red Panax ginseng, and various other ginseng preparations. Third, the duration of the interventions also varies, ranging from three weeks to 24 weeks. Fourth, the cognitive outcomes used are not standardized, making it difficult to directly compare results across studies (Takae et al., 2019; Park et al., 2019; Baek et al., 2024; Dormal et al., 2025).

Another limitation is that some of the mechanistic evidence still comes from preclinical models or reviews of biological mechanisms. Although this evidence is important for explaining how ginsenosides work, the results cannot yet be fully used as evidence of clinical efficacy in human . Therefore, mechanistic studies are more appropriately positioned as a biological basis supporting clinical findings, rather than as primary evidence of Panax ginseng's efficacy (Feng et al., 2022).

Implications for the Development of Cognitive Nutraceuticals

Based on the analyzed research findings, Panax ginseng has the potential to be developed as a natural ingredient in functional food products or nutraceuticals that support cognitive function. This potential is supported by clinical findings regarding improvements in memory, general cognitive function, sleep quality, stress, and certain executive functions (Baek et al., 2024; Dormal et al., 2025; Park et al., 2019).

However, the development of Panax ginseng-based products must take into account the standardization of extracts, ginsenoside content, dosage, dosage form, safety, and duration of consumption. This is important because variations in the content of active compounds and bioavailability can affect the product's effectiveness. Therefore, Panax ginseng-based nutraceutical products should be developed based on clear scientific evidence and supported by adequate clinical trials (Yang et al., 2020; Kim et al., 2025).

Summary of the Discussion

Overall, the analyzed research findings indicate that Panax ginseng has potential as a candidate for enhancing cognitive function. Clinical evidence suggests benefits across several outcomes, particularly memory, general cognitive function, stress, and specific executive functions. Mechanistic evidence supports the role of ginsenosides in regulating the cholinergic system, oxidative stress, inflammation, synaptic plasticity, and neurogenesis. However, variations in study populations, dosages, dosage forms, intervention duration, and measurement instruments remain major limitations. Therefore, further standardized research is needed to strengthen the evidence of the efficacy and safety of Panax ginseng as a candidate for enhancing cognitive function (Feng et al., 2022; Baek et al., 2024; Kim et al., 2025).

CONCLUSION

Based on the synthesis of preclinical and clinical evidence analyzed, Panax ginseng has the potential as a natural candidate to support improved cognitive function. This potential is particularly evident in the domains of memory, attention, executive function, and general cognitive performance. Several clinical studies have shown improvements in cognitive outcomes following administration of Panax ginseng or ginseng-based preparations, while mechanistic evidence supports the role of ginsenosides in regulating the cholinergic system, reducing oxidative stress, inhibiting inflammation, enhancing synaptic plasticity and neurogenesis, and protecting neurons.

Although the results of the review point to promising findings, the strength of the

evidence across studies still varies. Differences in study design, population, dosage, dosage form, duration of intervention, and cognitive assessment tools are factors that influence the consistency of the results. In addition, the bioavailability and metabolism of ginsenosides by gut microbiota must also be considered, as they can lead to variations in response among individuals.

Thus, Panax ginseng can be considered a potential candidate for the development of functional foods or nutraceuticals focused on cognitive health. However, claims regarding its effectiveness must still be presented proportionally, as further standardized clinical research is needed—involving larger sample sizes, adequate intervention durations, clearly defined dosages, and comprehensive measurements of cognitive outcomes. Future research should also address the safety of long-term use, the standardization of ginsenoside content, and individual factors that may influence the response to the intervention. With the strengthening of this evidence, Panax ginseng has the potential to become a relevant natural candidate for supporting the maintenance and enhancement of cognitive function based on scientific evidence.

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