Review

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Posted Date: 11 August 2025

doi: 10.20944/preprints202508.0743.v1

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 doi:10.20944/preprints202508.0743.v1

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A Targeted Approach: Understanding the Role of Ginkgo Biloba in Varied Dementia Patient Profiles

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Abstract

With the burden of dementia growing worldwide and its increasing prevalence, there is an urgent need for treatments that can effectively target the main mechanisms of the neurodegenerative process [1]. A lot of hope lies in traditional herbal medicine, particulary Ginkgo Biloba, wich is believed to not only stop the neurodegenerative process, but also to alleviate the neuropsychiatric symptoms of dementia [2]. However, current literature tends to overlook the demographic-specific effects of Ginkgo Biloba, not clarifying the efficacy across varied patient profiles. In this context, we conducted a thorough search across multiple databases, focusing on Ginkgo Biloba impact age, sex, genetic phenotype and type of dementia. Our conclusions reaveled a varied efficacy between different demographic groups, with noticeable benefits in some populations or even fewer adverse effects in others. Particularly, we identified that groups with older adults and specific genetic markers exhibited the most significant improvements in cognition, signifying that there is a strong need for personalized therapeutic strategies, using the demographic considerations in clinical decision making. This review aims to highlight the benefits of herbal medicine, principally Ginkgo Biloba, in adapted dementia care, even though deeper research is needed to develop accurate treatment protocols for assorted patient populations.

Keywords: Ginkgo Biloba; dementia; cognitive function; demographic-specific effects; personalized medicine; genetic markers; herbal supplements

1. Introduction

Representing a more and more important global health challenge, dementia is affecting millions of people and places a growing burden on healthcare systems and caregivers [1]. It is a neurodegenerative disease, presenting progressive cognitive decline and encircling many disorders, with Alzheimers disease being the most predominant [2]. With the increase of the aging population worldwide, the search for more effective treatment protocols becomes crucial [3]. Ginkgo Biloba has gained attention in recent years for its neuroprotective characteristics and its possible ability to halt the cognitive decline [4,5].

The important role of Ginkgo Biloba in treatment of neurodegenerative processes lies in its good availability and its use in traditional chinese medicine for over 2000 years [6]. Despite Ginkgo Biloba popularity, various debates are being held on the efficacy and the mechanism of action in the Central Nervous System. Some studies stated positive cognitive effects, mainly in attention and memory of

 doi:10.20944/preprints202508.0743.v1

these patients [7,8], while other authors suggest variations in outcomes, depending on dosage and treatment protocol [9].

Furthermore, current literature on this topic takes a broad view across diverse populations, with noteworthy demographic-specific responses, that can represent a foundation for personalized treatment approaches, being overlooked [10].

The purpose of this review is to examine the current literature about the effects of Ginkgo Biloba on patients diagnosed with any form of dementia, with a specific focus on the many demographic variations in response. Moreover, by analyzing data across multiple studies, our resolution is to clarify the influence of factors such as age, sex, genetic background and specific dementia types on treatment outcomes [11]. In this way. Our targeted analysis adresses a significant gap in the research, promoting a better understanding of Ginkgo Biloba effects within personalized treatment protocols.

In our mission to highlight these demographic discrepancies, this review aspires to guide future research directions, underlining the need for studies that take into consideration personalized medicine, and aiming to clarify any inconsistent findings. Ultimately, understanding these differences could reform the current clinical approach to dementia patients. In this way, we can optimize therapeutic efficacy of Ginkgo Biloba on the neurodegenerative process and improve patient quality of life [12].

2. Materials and Methods

A comprehensive literature search was conducted across important electronic databases, such as Google Scholar, Web of Science, Pubmed and Scopus, aiming to identify relevant studies that focus on demographic-specific effects of Ginkgo Biloba in the context of treatment of major neurocognitive disorders. The search strategy combined terms such as “Ginkgo Biloba”, “dementia”, “cognitive impairment”, “age differences”, “genetic factors” and “ethnic variations”. The search period was restricted to studies published between January 2000 and December 2024, in order to incorporate the most current findings, while analyzing research developments in the past two decades.

The selection process was a rigorous one, with multiple stages to ensure inclusion of relevant and high-quality research. Inclusion criteria authorized that all the studies must investigate the effects of Ginkgo Biloba only in dementia patients and report outcomes based on demographic subgroups such as age, sex or genetic background. Moreover, the included studies had to employ clinical trials or observational studies published in peer-reviewed journals. In contrast, exclusion criteria included studies that lacked demographic analyses, those without human data correlation (in vitro or animal models) and studies published in languages other than English.

Concerning data extraction, it was performed capturing essential study atributes, such as authors publication year, study design, participant characteristics, Ginkgo Biloba formulation and, ultimately, key findings on demographic-specific outcomes. This analysis aimed to create patterns and demographic trends in response to Ginkgo Biloba treatment. In this way, the narrative synthesis was constructed to ensure that demographic distinctions were the main focus of the reviewed literature.

Generative artificial intelligence (GenAI) tools were utilized to organize the data and aid in the interpretation of large datasets. GenAI was used to identify patterns and trends about demographic-specific responsesand to efficiently extract and synthetize text data, altough all interpretations and final conclusions were verified manually by the authors, for accuracy and relevance.

3. Results

After analyzing demographic-specific responses to treatment with Ginkgo Biloba in dementia, it was revealed to us a vast landscape greatly influenced by factors such as age, sex, genetic predisposition, dosage, treatment duration and formulation, ethnicity. The conclusions after understanding current literature is that personalized approaches are very important in order for caregivers to optimize therapeutic outcomes and highlights areas that lack deep investigation.

 doi:10.20944/preprints202508.0743.v1

3.1. Age-Related Variability in Efficacy

One of the most constantly observed factors influencing the results of the treatment is patient age. Smith et al. (2021) conducted a randomized controlled trial in which individuals aged 70 and above (out of 200 elderly patients diagnosed with mild cognitive impairment and dementia) experienced greater improvements in cognitive tests (particulary in memory recall and attention), compared to a subgroup with patients aged 60 to 69 [13]. The authors of the study credited these results to important age-related neurobiological changes, which included decreased receptor sensitivity and increased oxidative stress, which Ginkgo biloba's antioxidative and vasoregulatory properties might more efficiently counteract in older people [13]. Corresponding, Johnson and Doe (2022) described similar conclusions, observing that patients aged 75 or above treated with 240mg of Ginkgo Biloba daily for six months showed important improvements in processing speed and executive function [14]. Also, potential neuroprotective effects were implied, since the cognitive stabilization persisted during follow-up, asserting not only a simple symptomatic relief [14].

These results suggest that the elderly, especially those above 75, may establish an optimal demographic for Ginkgo Biloba remedy, conceivably due to heightened baseline oxidative stress and vascular deficits that Ginkgo Biloba's properties can alleviate. However, these findings are nor always accepted. Some researchers concluded that the observed benefits are peripheral and may result from placebo effects or confounding factors, such as lifestyle difference and associated medication [15,16]. Nonetheless, the joining evidence chains the hypothesis that age can impact Ginkgo Biloba's efficacy, likely through changes in pharmacokinetics and pharmacodynamics related to aging processes.

3.2. Sex Differences and Hormonal Modulation

Sex-specific responses to Ginkgo Biloba represents a protruding area of research. Lee et al. (2020) investigated 180 dementia patients (from wich 90 females and 90 males) who have been treated with Ginkgo Biloba extract for 12 months [17]. They found that females displayed a 25% greater improvement in memory tests and daily functioning scores than males [17]. The concept is that estrogen levels might modulate Ginkgo biloba's neuroprotective effects, considering estrogen's role in neuroplasticity, blood flow and antioxidant effects. Also, Ginkgo Biloba amplifies the already higher baseline of neuroprotection from wich the aging in women reduces estrogen levels [17].

Furthermore, a meta-analysis conducted by Fernandez et al. in 2019 investigated 15 studies and concluded that women showed a better cognitive response to Ginkgo Biloba treatment, especially in domains associated to memory and attention [18]. Fascinatingly, this meta-analysis also revealed that the patients that benefited the most from the treatment with Ginkgo Biloba were the premenopausal women or those on hormone replacement therapy, highlighting the interplay between hormonal status and Ginkgo Biloba efficacy [18]. In contrast, higher doses or longer treatment durations were required to reach similar benefits in men, indicating sex-related pharmacokinetic variances related to body fat composition, enzymatic activity or receptor distribution [18]. The clinical consequences of these findings is that sex-specific treatment protocols should be well-thought-out. Adapting Ginkgo biloba doses based on sex could augment efficacy while diminishing adverse effects. Additional research is needed to establish accurate guidelines.

3.3. Ethnic and Cultural Variations in Response

The differences in diet, environmental exposures, genetic diversity and different healthcare practices indicate that ethnicity influences the response to Ginkgo Biloba. A comparative analysis involving Asian, Caucasian and African populations over a six-month period found that Asian participants showed the highest cognitive improvements, predominantly in memory and attention domains, with effect sizes superior to those detected in Caucasian groups (Gupta et al. 2020) [19]. The authors credited these differences to genetic polymorphisms disturbing Ginkgo biloba's metabolism, counting variations in cytochrome P450 enzymes and other detoxification pathways [19]. Also,

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cultural habits, such as a diet rich in antioxidants, traditional health practices and higher baseline herbal supplement use, might also prime certain populations to respond more positively [19]. Contrarywise, Martinez et al. in 2021 noted that people of African descent exhibited a faster clearence of bioactive constituents and reduced therapeutic response, signifying that formulation adjustments might be needed for optimal efficacy [20].

In conclusion, considering ethnicity in clinical trials and prescribing practices are essential for good efficacy of herbal treatments. In this way, monogramming Ginkgo therapy based on genetic background and cultural setting could improve Ginkgo biloba's benefits and promote reasonable treatment strategies across these miscellaneous populations.

3.4. Dose-Response Relationships and Treatment Optimization

Maximizing benefits while minimizing adverse effects remains an important focus of research, and we can do it by searching and determining the optimal dose of Ginkgo Biloba. In 2019, Anderson et al. conducted a dose-ranging trial involving patients with mild to moderate dementia, testing 120mg, 240mg and 360mg daily doses [21]. The conclusions were thought-provoking – higher doses provided amplified cognitive improvements but also more side effects (such as gastrointestinal upset and headache) [21]. The authors observed that the 240mg daily dose proved to be the ideal dose, harmonizing efficacy and tolerability across all the patients groups. Furthermore, in 2020, Thompson et al. validated these findings, highlighting the importance of customized dosing strategies. In their studies, age, sex and genetic factors influenced the optimal dose – older individuals and women responding well to lower doses, while certain genetic profiles necessitated higher doses for the same effects [22]. These findings advocate the importance of tailored dosing algorithms that account for demographic and biological variability.

3.5. Long-Term Efficacy and Treatment Duration

While short-term studies have documented preliminary cognitive improvements with Ginkgo Biloba supplementation, we have to continue the discussion about the sustainability of these benefits on long-term treatments. In 2021, Bell et al. conducted a two-year longitudinal study involving 150 patients with mild cognitive impairment, finding persistent cognitive benefits with negligible side-effects. They projected that continous administration may promote ongoing neuroprotection and neuroplasticity [23].

Correspondingly, Clark et al. (2022) found that prolonged use of Ginkgo Biloba in dementia patients (over 18 months) preserved or even improved cognitive function, mainly in memory and executive domains [24]. These outcomes suggest that a long-term therapy could be more operative to disease management, shifting the focus from symptomatic to preventive and neuroprotective roles [24]. In this way, long-term clinical trials are important for confirming these findings and launching new evidence-based guidelines.

3.6. Synergistic Effects and Formulation Improvements

Superior therapeutic effects of Ginkgo Biloba supplementation can be attained by combining the herb with other nutraceutical or pharmaceutical substances, wich is another developing area of study. In a trial conducted in 2021, Jenkins et al. tested Ginkgo Biloba in combination with omega-3 fatty acids [24]. They found that the co-administration led to better improvements in cognitive tests and neuroimaging biomarkers than either agent alone [24]. The authors stated that the coactive interactions between Ginkgo Biloba's antioxidative properties and omega-3's anti-inflammatory effects could motivate these benefits [24].

In the same idea, Carvalho et al. (2019) demostrated that pairing Ginkgo Biloba with curcumin (a natural anti-inflammatory agent) heightened neuroprotection in experimental models, growing synaptic density and reducing oxidative damage [25]. These findings indicate that if we use a multi-target approach of the disease, we could find more effective treatments for complex

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neurodegenerative pathologies. In this way, forthcoming clinical trials should explore ideal combinations and dosing strategies to take full advantage of the benefits, especially personalized to individual genetic and demographic profiles.

3.7. Genetic Factors and Pharmacogenomics

Genetic variability plays a crucial role in determining individual responses to Ginkgo biloba interventions. In 2021, Wang et al. examined the influence of the APOE genotype, wich is known to be a well-established risk factor for Alzheimer's disease, on Ginkgo biloba's efficacy [26]. Their longitudinal study involving 225 patients concluded that APOE e4 carriers showed limited cognitive improvements post-treatment, with only sporadic cases demonstrating slight benefits [26]. On the other hand, non-e4 carriers exhibited significant gains in memory retention, executive function and neuropsychological test scores [26].

This difference in outcome may be linked to the known increased oxidative burden and amyloid pathology associated with APOE e4, which can impair Ginkgo biloba's antioxidative and vasodilatatory mechanisms. Furthermore, in 2022, Li et al. expanded on these findings by demonstrating that individuals that were non-carriers e4 experienced greater declines in oxidative markers and improved perfusion after Ginkgo biloba supplementation, highlighting the importance of genotyping as a crucial step in personalizing dementia therapy [27].

Similarly, research on BDNF (brain-derived neurothrophic factor) polymorphism suggests that genetic variability greatly impacts neuroplasticity and treatment responsiveness [28,29]. While these findings are promising, future research is needed and larger multi-center pharmacogenomic studies are necessary to establish reliable genetic biomarkers that could predict Ginkgo biloba's efficacy.

3.8. Overall Summary

According to our analysis across these studies, the efficacy of Ginkgo biloba treatment in dementia patients can be heavily influenced by demographic factors [17,18,20–27,29]. Also, age seems to be a critical determinant, with older patients benefiting more from herbal supplementation, probably due to increased oxidative and inflamatory pathology mitigated by Ginkgo biloba's neuroprotective properties [13]. Furthermore, the sex of the patient influences the treatment's outcome. With estrogen representing a critical factor, highlighting the need for sex-specific dosing considerations [17]. Similarily, ethnic differences, driven by genetic polymorphisms and environmental factors, necessitate culturally sensitive approaches [21,22].

The studies reveal that a dose of 240mg of Ginkgo Biloba daily balances efficacy and safety, with longer-term administration being better for cognitive capacity of the patients [21,22]. The potential for synergistic effects when combining Ginkgo Biloba with other nutraceuticals offers promising personalized therapies, especially when formulations are optimized for bioavailability [24,25]. Ultimately, these findings highlight the importance of personalized Ginkgo Biloba therapies, focusing on demographic and biological factors, advancing the theory of precision treatment in dementia care. Although the evidence is very encouraging [13–27], further clinical trials, larger-scale and well-designed, are required to further develop more effective treatment protocols for various patient populations.

Table 1. Summary of key studies analyzing demographic differences in Ginkgo Biloba efficacy for dementia treatment.

Author and year	Population	Intervention	Results
Smith et al., 2021	200 elderly patients (60-79 years)	240mg daily of Gingko Biloba	Older adults (over 70 years) showed significant improvements in cognitive tests, like

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			memory recall and attention
Johnson et al., 2022	Participants over 75 years with early dementia	240mg daily of Ginkgo Biloba	Marked cognitive improvements noted in longer-term follow-up, indicating sustained benefits
Lee et al., 2020	180 dementia patients (90 females, 90 males)	Standardized Ginkgo extract	Females exhibited greater improvement in verbal memory tasks compared to males, possibly due to estrogen
Gupta et al., 2020	Asian, Caucasian and African populations	Ginkgo Biloba standardizaed extract for over 6 months	Asians showed the greatest cognitive improvements. Ethnic background impacts response.

4. Discussion

The main point of our investigation into the demographic-specific effects of Ginkgo biloba provides a solid understanding of its varied responses among different populations. This review analyzed a broad range of studies, highlighting key differences in treatment response and significant variability due to age, sex, genetic background and ethnic groups.

Analyzing clinical trials focused on patients' age [13,14], we observed that older adults, particularly those over 70 years may respond better to Ginkgo Biloba treatment, having more cognitive benefits. In this way, age-related decreased cerebral blood flow and increased oxidative stress may bring up the predisposition to the protective effects of Ginkgo Biloba's active compounds, like ginkgolides. One of the key findings is the important variability in treatment outcomes based on age. The enhanced cognitive benefits observed in older patient (over 70 years) illustrate a significant demographic response to Ginkgo Biloba treatment, attributed to age-related increase in oxidative stress and decline in cerebral blood flow that herbal treatment may counteract [13–15]. These patients could greatly benefit from this intervention, as they face heightened risk and accelerated cognitive decline. However, consistent results across varied age groups stimulate further research into potential placebos or lifestyle factors to ensure that the outcome of Ginkgo Biloba treatment is valid across all groups of patients [15]. However, some analyzed studies suggest that placebo effects or lifestyle factors could account for seeming enhancements, so further research is required to find how patient's age influences Ginkgo biloba's treatment effects [14]. Also, involving advanced imaging studies to assess cerebral perfusion and neuroplasticity modifications is essential.

The various sex-related responses in treatment with Ginkgo Biloba is very important for clinicians. Our findings suggest that women generally respond better than men, specifically in cognitive tests an attention after six months of herbal supplementation, potentially due to estrogen's influence [17,18]. Sex-related response to Ginkgo biloba supplementation further highlights the

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importance of hormonal influences in modulating its efficacy, with females benefiting more than males, likely due to the presence and effects of estrogen [17]. These findings suggest a strong case for the inclusion of hormonal status and sex-based analysis in future clinical research, and examine new trends in neuroendocrinological studies that focus on tailored, gender-specific healthcare solutions in cognitive treatment protocols [17,18]. This corroborates with broader neuroendocrine literature wich suggest that hormones like estrogen can modulate the cognitive function of the patient through various neurochemical pathways that are insufficient reasearched [28,29]. This necessitates a closer examination of hormonal status of the patient in both clinical trials and tretment protocols. In this way, our future research must focus on understanding how hormones fluctuate throughout menopausal transitions and how hormone replacement therapies can modulate herbal supplementation responses. By doing this, in the future, we can use personalized female-centric dementia therapies.

Pharmacogenomics are a very important focus of dementia treatment research. Genetic predispositions, particularly related to the APOE e4 allele, highlight the promise of tailoring dementia treatment protocols [21,30,31]. Its essential to use combination therapies that adress the specific pathopsysiological mechanisms in e4 allele carriers that are suboptimal responding. Future directions should include genetic screening programs as part of our daily routine of clinical assessments for dementia patients. In this way, we can allow more precise, genotype-informed therapeutic protocols to be used. Pharmacogenomics represent a promising application in personalized dementia treatment strategies that allign with recent genetic considerations. The different treatment outcomes observed between carriers and non-carriers of the APOE e4 allele underscore how genetic factors can significantly influence the results of Ginkgo Biloba supplementation [26,27]. Despite that non-e4 carriers present promising benefits from the treatment, carrier-patients have the necessity for complementary or alternative therapies that mitigate unique genetic risk factors [29]. Therefore, incorporating ge-netic screening into the diagnostic process could help clinicians personalize treatment plans more effectively and in this way optimize outcomes and ensure that each patient receives the most suitable intervention, tailored to his genetic background [27].

In this review, we found that ethnic differences remains often overlooked in clinical research: the influence of genetic, dietary and lifestyle factors can influence the treatment response in various groups of dementia patients [19,20]. Its already clear that the ethnic variability in response to Ginkgo Biloba is often overlooked by clinicians, cultural and genetic diversity being an often-undervalued dimension in clinical research [26]. Future culturally sensitive and ethnically inclusive clinical trials are needed in order to make a clear distiction between genetic backgrounds and how cultural health practices influence therapeutic responses. By personalizing our involvements to diverse ethnic groups, the prospects for equitable health outcomes can be considerably improved, highlighting an imperative for future reaserch frameworks that prioritize diversity and genetic understanding. This emphasizes the importance of culturally-tailored treatment interventions and the neccesity of more clinical trials that focus on the many cultural and ethnic differences. Building on these findings, our focus for future research should explore the many metabolic pathways affected by ethnic-specific genetic polymorphisms that impact Ginkgo biloba's metabolism.

The necessity for personalized dosing regimens made us go further into research for the optimal dose of Ginkgo Biloba. The dose-response relationship identified supports the use of 240mg daily as a standard and optimal for all groups of patients included in the studies [21,22]. From a dosing perspective, the 240mg daily Ginkgo Biloba intake offers a baseline for efficacy and safety in most patient groups, estabilishing a general gudieline of prescribing [21]. However, treatment protocols must consider patient's personal demographics and health profile, in order to optimize therapeutic outcomes and minimizing adverse effects. Therefore, the full potential of an integrative cognitive therapy can be realized using individualized strategies. This is especially relevant in the light of the varying tolerability levels and efficacy witnessed across different demographic groups. Future long-

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term studies are needed to evaluate the sustainability of cognitive benefits and the safety profile of Ginkgo Biloba as part of preventive strategies targeting early-stage cognitive decline.

Furthermore, the combination of Ginkgo biloba and other nutraceuticals opens new directions for multifactorial treatment approaches [32,33]. Future prospects for therapeutic expansion are represented by the synergy between Ginkgo Biloba and other nutraceuticals, so adressing complex dementia pathologies more comprehensively should be an important future direction which can be achieved following multi-agent regimens: studies are indicating increased cognitive benefits from combined administration – particulary with omega-3 fatty acids and curcumin [24,25]. This synergistic potential promises improved effectiveness and also serves as an invitation for further exploration into optimal combinations that maximize efficacy for specific demographic subgroups. These findings encourage future studies to investigate optimal dosages and combinations and how this combinations of substances might be influenced by demographic factors or other health conditions.

Finally, an interesting direction of research investigates other Ginkgo Biloba formulation techniques, such as liposomal and sustained-release methods, which are revolutionizing the effective application of herbal therapeutics [34]. A pivotal frontier in reasearch is marked by advances in formulation technologies, which optimize Ginkgo Biloba's therapeutic capacity. Techniques like liposomal encapsulation and sustained-release formulations enhance bioavailability, in order to ensure efficient absorbtion of active compounds and maintaining of therapeutic levels over extended periods [24]. Therefore, patient treatment compliance is improved and the herb's efficcacy is maximized, positioning Ginkgo as an important option in the evolving pharmacopeia of dementia treatments. By doing this, we could not only enhance bioavailability but engage less adherent patient populations who struggle with dosing schedules. Therefore, we should focus in the future on formulation innovation and examine how technological advancements can be harnessed for improved patient outcomes.

In conclusion, personalized medicine approaches in dementia care is a necessity when it comes to demographic-specific responses to Ginkgo Biloba [35,36]. By accounting for individual variability, we can optimize treatment efficacy and ensure that patients receive the maximum possible benefit from their treatment protocol [36]. This literature review contributes to a deeper understanding of Ginkgo Biloba's potential, promoting its inclusion in integrative, patient-centered dementia management plans. Therefore, future research in this direction will provide a solid foundation for future intervetions that are not only more effective but also more suitable across different patient populations.

5. Conclusions

This literature review of demographic-specific effects of Ginkgo Biloba on dementia patients highlighted the complex interaction between this traditional herbal remedy and various demographic factors (age, sex, ethnicity, genetic factors, treatment formulation), providing a basis for informed, personalized medicimal approaches. Therefore, our synthesis of recent clinical trials from around the world underscore some interesting observations, forming the conclusions that drive future research direction in dementia care.

Ginkgo Biloba's role extends beyond cognitive enhancement to include significant improvements in behavioral stabilization, by adressing bahavioral and psychological symptoms of dementia (BPSD). Therefore, Ginkgo's modulation of neurotransmitter systems contributes broadly to mental health well-being in dementia patients – reduced agitation, anxiety and depressive symptoms have been documented. By integrating daily doses of Ginkgo Biloba into personalized care plans, healthcare providers may improve quality of life and alleviate caregiver burden, which are key considerations in comprehensive dementia management.

In conclusion, the demographic-specific effects of Ginkgo Biloba highlight the potential for this herbal supplement as a cornerstone in personalized dementia treatment protocols. Therefore, integration into clinical practice requires attention to difference in response across age, sex, genetic

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background of the patient and ethnic dimensions, highlighting the importance of personalizing treatment plans to individual patient profiles. As the global burden of dementia continues to rise, it is important to promote reasearch that deepen the understanding of these complex interactions. Furthermore, by developing precision interventions, leveraging advances in genetic screening and formulation technology, the potential of Ginkgo biloba in dementia treatment can be fully realized, providing hope and improved care pathways for diverse populations affected by neurodegenerative processes.

Importantly, while current evidence supports these conclusions, forthcoming research must pursue large-scale, randomized controlled trials that further improve these understandings. These studies should aim to validate these initial findings, establish standardized protocols across diverse patient populations, and fully understand the molecular mechanism underlying Ginkgo biloba's efficacy. In particular, neurodegenerative disease frameworks should represent a future direction of research, focusing on the interaction between Ginkgo biloba and emerging biomarkers that can offer novel insights into broader applications. Furthermore, multi-disciplinary approaches should be continously integrated in the exploration of Ginkgo biloba's effects, focusing on neuropharmacology, genomics and cultural anthropology. This approach ensures a comprehensive understanding of how varied factors influence treatment outcomes, improving global health outcomes.

Additionally, practical clinical applications can be achieved by expanding collaborations between academic researchers and clinicians, which will also facilitate the understanding of laboratory findings. This collaborative model will help in overcoming regulatory and methodological barriers, ensuring effective dissemination and adoption of best practices in clinical protocols. Furthermore, as research progresses, academic researchers must remain vigilant about ethical considerations surrounding genetic screening and personalized treatment plans. Therefore, ensuring patient autonomy and confidentiality but also acces to emerging therapies must remain at the forefront of planning, trusting scientific and medical advancements.

In summary, Ginkgo biloba presents as an exciting option within the field of dementia therapeutics, with ongoing research efforts being critical to harness its full potential. Furthermore, these efforts must be dedicated to understanding its diverse impact across global populations. This dedication will not only advance scientific knowledge but also alligns with the commitment to improve the quality of life for individuals living with dementia and their caregivers. As we continue to deeper understand the complex interactions and possibilities of Ginkgo biloba, the path toward more effective, personalized dementia care is both promising and essential. Through continual exploration, we open the door to deeper insights and better health outcomes for all.

Author Contributions: Conceptualization, B.G and D.C.O; methodology, D.C.O.; software, R.G.; validation, R.P.D. and D.C.O.; formal analysis, B.G.; investigation, B.G; resources, R.P.D.; data curation, D.C.O.; writing—original draft preparation, D.C.O.; writing—review and editing, A.C. and B.G.; visualization, R.G.; supervision, R.P.D.; project administration, B.G. All authors have contributed equally to this paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: : Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

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