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(RESEARCH ARTICLE)

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Formulation and Evaluation of Polyherbal Gummies for Alzheimer's disease

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Abstract

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by cognitive impairment, memory loss, and behavioral disturbances. Conventional therapeutic approaches offer limited efficacy and are often associated with adverse effects, highlighting the need for safer and more effective alternatives. This study focuses on the formulation and evaluation of polyherbal gummies incorporating standardized extracts of Ashwagandha (*Withania somnifera*), Tulsi (Ocimum sanctum), and Turmeric (*Curcuma longa*), Guava leaves (Psidium guajava), selected for their well-documented antioxidant, anti-inflammatory, and neuroprotective properties. The gummies were prepared using a sugar-based soft matrix, ensuring high palatability and patient compliance, particularly in elderly populations. Standardized evaluation parameters, including organoleptic properties, weight variation, pH, texture analysis, antioxidant assays (DPPH, FRAP), acetylcholinesterase (AChE) inhibition assay, and microbial testing, were conducted to determine the quality and efficacy of the formulation. The formulated gummies showed desirable physical characteristics, acceptable taste, and uniform weight distribution. Antioxidant assays revealed significant free radical scavenging activity, with notable DPPH inhibition percentages and strong ferric reducing antioxidant power (FRAP). AChE inhibition studies indicated moderate suppression of enzymatic activity, suggesting potential cognitive enhancement and neuroprotection against Alzheimer's-related neurodegeneration. Microbial analysis confirmed the microbiological safety of the product within acceptable pharmacopeial limits.

Keywords: Polyherbal gummies; Alzheimer's dcan beease; Ashwagandha; Tulsi; Turmeric; Guava leaves Neuroprotection; Antioxidants

1 Introduction

Alzheimer's dcan beease (AD) can be gradually worsening neurological condition marked by declining memory, impaired cognition, dysfunction, behavioral changes, and functional dcan beability. It can be associated with the accumulation of amyloid-beta plaques, neurofibrillary tangles, oxidative stress, inflammation, and neurotransmitter imbalance in the brain. According to the World Health Organization, Alzheimer's dcan beease can be one of the leading causes of death and dcan beability among the elderly population worldwide. Current pharmacological treatments only offer temporary symptomatic relief and have been often associated with adverse effects, creating a need for safer and more effective alternatives.

Medicinal plants have gained significant attention for their potential to prevent and treat neurodegenerative dcan beeases through multi-targeted actions such as antioxidant, anti-inflammatory, anti-amyloid, and neurotransmitter modulating effects. Ashwagandha (*Withania somnifera*) can be well Recognized for its ability to neuroprotective, Mental relaxation and memory enhancing capabilities. Tulsi (Ocimum sanctum) has demonstrated anti

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oxidant and anti-inflammatory effects, while Turmeric (*Curcuma longa*) possesses curcumin, a potent antioxidant and anti-amyloid agent. Traditionally, these herbs have been used in Ayurveda for brain health and rejuvenation. To enhance patient compliance and improve the bioavailability of these herbal extracts, that can be study focuses on the formulation and evaluation of polyherbal gummies.

The oral route remains the most widely used and preferred method for administering medications due to its simplicity, safety, and suitability for self-administration. Despite its advantages, it presents challenges for specific populations—particularly children and the elderly—who often suffer from dysphagia, or difficulty in swallowing. This condition makes it hard to ingest solid dosage forms such as tablets or capsules, and even liquid preparations pose a choking hazard. As a result, individuals may crush tablets or open capsules to mix with food or liquids, which can lead to inaccurate dosing, altered drug release, and an unpleasant taste, potentially compromising treatment efficacy and safety.

To overcome these issues, gummies have emerged as a favorable alternative dosage form. These chewable, gelatinous formulations are easier to handle and consume, require no water, and reduce the risk of choking—making them particularly suitable for pediatric and geriatric use. With their pleasant taste, attractive appearance, and blend of solid-liquid characteristics, gummies enhance patient compliance. Once mainly marketed for children, gummies are now increasingly accepted among adults as well. The global market for gummy formulations is projected to grow significantly, potentially reaching $4.17 million USD by 2025. Gelatin remains a commonly used gelling agent in gummy production, contributing to their desirable texture and structural integrity.

1.1 Ashwagandha (*Withania somnifera*)

Ashwagandha, scientifically known as *Withania somnifera* and belonging to the Solanaceae family, is traditionally referred to as “Indian Winter Cherry” or “Indian Ginseng.” The root is the primary part used medicinally. The name “Ashwagandha” originates from the Sanskrit word “ashwa” meaning horse, reflecting the belief that the herb imparts strength and vitality akin to that of a horse. The suffix “gandha” means smell, referring to the distinctive aroma of the fresh root.

Renowned in Ayurvedic medicine, Ashwagandha has been used for centuries as a nervine tonic, helping to rejuvenate and stabilize the nervous system. Its major bioactive components include alkaloids (such as isopelletierine, anaferine, cuseohygrine, anahygrine), steroidal lactones (notably withanolides and withaferins), and saponins. Among these, sitoindosides and acylsterylglucosides are recognized for their potent anti-stress properties. Key active compounds like Withaferin-A and sitoindosides VII–X have been shown in research to significantly mitigate stress responses in experimental models, reinforcing the herb’s reputation as a natural daptogen.

Figure 1 *Withania somnifera* root

1.2 Turmeric

Turmeric (*Curcuma longa*), a member of the Zingiberaceae family, can be widely recognized for its medicinal properties and therapeutic applications. The rhizome (underground stem) can be the primary part used, often processed into a bright yellow powder known as turmeric powder. It can be rich in bioactive compounds such as curcuminoids (mainly curcumin), volatile oils (including turmerone and atlantone), proteins, and starch. Turmeric exhibits a wide range of pharmacological activities, including potent antioxidant, anti-inflammatory, and neuroprotective effects. Curcumin, its principal component, can be particularly effective at scavenging reactive oxygen species (ROS), reducing oxidative stress, and inhibiting inflammatory mediators such as COX-2 and cytokines. In the context of Alzheimer's dcan beease, curcumin has been shown to reduce amyloid plaque accumulation, protect neuronal integrity, and improve cognitive function. In polyherbal gummies, turmeric powder contributes significantly to the antioxidant and anti-inflammatory properties, thereby enhancing the neuroprotective potential of the formulation. For conscan betent results, standardized turmeric extract with known curcumin content can be preferred in dosage formulations. Turmeric also imparts a natural yellow coloring to gummies, eliminating the need for synthetic dyes.

Figure 2 Turmeric Rhizome's

1.3 Tulsi

Tulsi (Ocimum sanctum), also known as "Holy Basil," belongs to the Lamiaceae family and holds a sacred place in traditional Ayurvedic medicine due to its wide range of therapeutic benefits. The leaves have been rich in various bioactive compounds such as eugenol, ursolic acid, rosmarinic acid, apigenin, luteolin, and other flavonoids. Tulsi can be renowned for its antioxidant, anti-inflammatory, adaptogenic, and neuroprotective properties. Its antioxidant activity helps in scavenging free radicals, thereby reducing oxidative stress, which can be one of the major contributors to neurodegenerative dcan beeases like Alzheimer's. Tulsi also modulates neurotransmitters like dopamine and serotonin, supporting cognitive function and mood balance. In addition, it has shown potential in protecting neurons against β-amyloid toxicity, a hallmark of Alzheimer's dcan beease pathology. When incorporated into polyherbal gummies, Tulsi not only enhances the neuroprotective effect but also adds a mild herbal flavor, contributing to the overall therapeutic and sensory quality of the formulation.

Figure 3 Tulsi Leaves

1.4 Guava leaves

Guava leaves (Psidium guajava) have been rich in flavonoids and phenolic compounds, which possess strong antioxidant properties. These compounds may protect neurons from oxidative damage and enhance cognitive function. Preliminary studies indicate that extracts from guava leaves can improve memory and learning abilities, making them a promcan being candidate for AD management.

Figure 4 Guava Leaves

1.5 Health benefits of Polyherbal Plant

- Anti-stress
- Anti-inflammatory
- Neuroprotective
- Congestive Boost

- Antimicrobial
- Immune Booster

1.6 Side Effects Of Polyherbal Plant

The polyherbal formulation conscan beting of Ashwagandha, Tulsi, Guava leaves, and Turmeric offers numerous therapeutic benefits; however, mild side effects have been observed when consumed in excessive quantities. Ashwagandha may cause gastrointestinal dcan beturbances such as stomach upset, diarrhea, and drowsiness at higher doses. Tulsi, although generally well-tolerated, may lead to mild nausea or blood thinning effects, requiring caution in individuals on anticoagulant therapy. Guava leaves, known for their antidiabetic properties, might occasionally cause constipation or hypoglycemia if consumed excessively. Turmeric, rich in curcumin, can irritate the stomach lining or contribute to kidney stone formation when taken in large quantities. Overall, the side effects have been minimal and typically dose-dependent, and proper formulation ensures safe consumption, particularly in polyherbal gummies designed for neuroprotective and antioxidant purposes in Alzheimer's dcan beease management.

1.7 Advantages of gummies

Gummies have several advantages over pills, capsules, or liquids:

- Taste: They're often tastier and easier to swallow.
- Easy Consumption: They're simple to chew and swallow, suitable for all ages.
- Portability: They're individually wrapped or come in small packages, easy to carry.
- No Water Needed: Unlike pills, they don't require water for consumption.
- Mask Unpleasant Tastes: They can hide the taste of medications.
- Variety of Flavors: They come in many flavors to suit preferences.
- Less Intimidating: Their fun shapes and colors make them less scary for some people.

1.8 Herbal Extracts Medicated Gummies

Medicated gummies are an innovative and patient-friendly oral dosage form that combines the therapeutic benefits of herbal extracts with the appealing format of chewable candies. In the present study, herbal extracts such as Ashwagandha (*Withania somnifera*), Tulsi (Ocimum sanctum), and Turmeric (*Curcuma longa*) were utilized to prepare polyherbal gummies aimed at managing symptoms related to Alzheimer's disease, including neurodegeneration, oxidative stress, inflammation, anxiety, and cognitive decline. The gummies were formulated without the use of gelatin, focusing instead on sugar-based and natural gelling agents to ensure stability, palatability, and better shelf-life at room temperature. Each gummy was carefully prepared to deliver a precise amount of active phytoconstituents with known antioxidant, anti-inflammatory, and neuroprotective properties. The polyherbal formulation leverages the synergistic actions of these plant extracts to modulate neurotransmitters such as GABA and serotonin, providing cognitive support and neuroprotection. These medicated gummies offer advantages such as easy administration, enhanced patient compliance, improved taste, and natural origin of therapeutic agents, making them highly suitable for geriatric populations suffering from cognitive disorders like Alzheimer's disease.

Aim and objective

Aim: To formulate and evaluate polyherbal gummies containing Ashwagandha, Tulsi, Guava leaves, and Turmeric for their neuroprotective, antioxidant, and anti-inflammatory effects in the management of Alzheimer's dcan beease.

Objective

- To prephave been gummies using Ashwagandha, Tulsi, Guava leaves, and Turmeric.
- To evaluate the gummies for antioxidant, anti-inflammatory, and neuroprotective activities.
- To check the physical properties like taste, weight, texture, and stability.

2 Material and Method

2.1 Materials Required

- Powder of herbs (such as ashwagandha roots, turmeric rhizome, and tulsi leaves)
- Solvent (hydroalcoholic mixture of ethanol and water, in a ratio of 70:30)
- Maceration Process

- Beaker
- filter paper, funnel

2.2 Preparation of Powder of Herbs for Extraction

- Dried plant materials have been pulverized into fine powders using a mortar and pestle.
- Chave been can be taken to ensure uniform particle size for efficient extraction.
- Plant powders have been dried to remove residual mocan beture.

2.3 Selection of Solvent

- A hydroalcoholic solvent (mixture of ethanol and water) can be chosen for improved extraction efficiency.
- The ethanol-water mixture ratio can be 70:30.

2.4 Maceration Process

The powdered plant materials had been combined and placed in a clean glass container. Solvent (about 10 times the weight of powder) was added, enough to completely immerse the powder. The mixture was sealed and allowed to stand for 72 hours at room temperature, with occasional shaking for better extraction.

After 72 hours, the mixture was filtered through muslin cloth and then through Whatman filter paper No.1 to remove plant debrcan be.

The filtrate (combined herbal extract) was concentrated using a rotary evaporator at 40–45°C under reduced pressure to remove the solvent. A thick, semi-solid mass of combined herbal extract was obtained.

The final extract was stored in an amber-colored container at 4°C for further use in formulation of gummies.

2.5 Preparation of Gummies

- Gelatin powder, acting as a substitute, was dissolved in water to create a gel base.
- Stevia was added to the gel base for sweetness, ensuring the palatability of the gummies.
- Herbal extracts of ashwagandha, , Turmeric, and tulsi, obtained through Maceration process for efficient extraction of bioactive compounds, were added to the gel base.
- Vanilla Essence was introduced for flavor enhancement, enhancing the taste profile of the gummies.
- The mixture was heated and stirred until all ingredients were thoroughly combined, ensuring uniform distribution of herbal extracts and other components.
- Once the mixture reached a uniform consistency, it was poured into molds, forming the desired gummy shape.
- The filled molds were allowed to set at room temperature, allowing the gummies to solidify and take shape.
- After solidification, the gummies were carefully removed from the molds, resulting in the final product being ready for subsequent evaluation.

2.6 Formulation Table

Table 1 Formulation table of Gummies

Sr.no	Ingredient	F1	F2	F3	F4	Uses
1	Aswagandha Extract	1g	1.5g	2g	2.5g	Adaptogenic properties and stress reduction
2	Tulsi leaves Extract	0.5g	0.5g	1g	1g	Stress reduction
3	Turmeric Extract	0.5g	0.5g	0.5g	1g	potent antioxidant and anti-amyloid agent
4	Guava Leaves Extract	0.5g	1g	1g	1.5g	Antioxident,anti-inflammatory and nuroprotective effect
5	Gelatin	4g	4g	4g	4g	Gelling agent
6	Citric acid	0.2g	0.2g	0.2g	0.2g	Preservative
7	Stevia	30g	30g	30g	30g	Sweetening agent
8	Water	q.s	q.s	q.s	q.s	Solvent

9	Orange Food Colour	1-2 drops	1-2 drops	1-2 drops	1-2 drops	Natural Colouring agent
10	Vanilla Essence	1-2 drops	1-2 drops	1-2 drops	1-2 drops	Flavouring agent

2.7 Evalution parameter

2.7.1 Appearance

The prephave beend polyherbal gummies had been smooth, semi-solid, and jelly-like in texture. They had a uniform shape, slightly glossy surface, and natural browncan beh-yellow to light green color depending on the herbal extract concentration. No cracks, air bubbles, or phase separation had been observed.

2.7.2 Texture

The texture of the gummies was soft, chewy, and resilient. They were easy to bite without being sticky or brittle. The use of agar or gelatin provided good firmness and elasticity, ensuring acceptable mouthfeel.

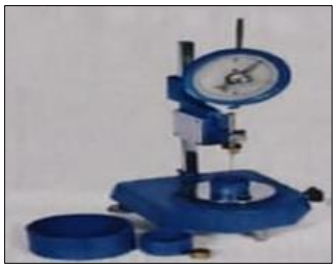

Figure 5 Firmness Testing

Figure 6 Hardness tester of gummies

2.7.3 Odour

The gummies had a mild, pleasant herbal aroma due to the presence of Ashwagandha, Tulsi, Guava leaves, and Turmeric. There was no foul or irritating smell, indicating good formulation and stability.

2.7.4 Colour

The colour of the gummies ranged from light brown to yellowish-green, influenced by the natural pigments of Turmeric and Guava leaf extract. The colour was uniform throughout each gummy and visually acceptable without artificial additives.

Figure 7 Images of Gummies

2.7.5 Determination of pH

A 10% v/v Gummy solution was constituted in dcan betilled water, and the pH of the solution was measured using a calibrated pH meter.

Figure 8 pH of Gummies

2.7.6 Mouth Feel

The gummies exhibited a smooth, soft, and chewy mouth feel with a pleasant consistency. They dissolved gradually without leaving any gritty or bitter residue, making them palatable and patient-friendly.

2.7.7 Weight Variation Test

The weight variation test ensures uniformity in the dosage form. For 2 g gummies, individual gummies had been weighed, and the average weight was calculated. The deviation of each gummy from the average was checked.

Acceptance Criteria: According to pharmacopeial standards, the individual weight should not deviate by more than ±5% from the average weight for units >250 mg.

Average weight: 2.0 g Acceptable range: 1.9 g to 2.1 g8.

2.7.8 Stability Study

A stability study can be essential to ensure that polyherbal gummies maintain their quality, efficacy, and safety throughout their shelf life. The study evaluates the physical, chemical, and microbiological stability of the gummies under various storage conditions over time. Polyherbal gummies have been typically stored at room temperature (25 ± 2°C), accelerated conditions (40 ± 2°C with 75 ± 5% RH), or refrigerated (5 ± 3°C with low humidity) for up to three months.

2.7.9 Stickiness

The texture of the medicated jelly in terms of stickiness had been evaluated by vcan beual inspection of the product after mildly rubbing the jelly sample between two fingers.

2.7.10 Dcan be solution

Racan bee the temperature of the dcan besolution medium, namely water, to between 36.5 and 37.5° Place one dosage unit (gummy) in the apparatus, cover the vessel, and run the apparatus at the specified rate. After 2 hours of operation in the acid medium, withdraw a portion of the liquid and proceed promptly as instructed for the Buffer stage.

Figure 9 Dissolution Apparatus

2.7.11 Gummy absorption

Put a gummy in a glass of water and observe how long it takes for the gummy to dcan besolve.

2.7.12 Dcan be solution of gummies

Dissolution studies serve as a common method to mimic the in vitro behavior of pharmaceutical dosages, predicting their bioavailability and effectiveness. As depicted in the figure, formulations released nearly 100% of their content within 120 minutes, yet their dissolution profiles varied significantly. One Formulation exhibited concentrations reaching close to 100% after 15 minutes, indicating more immediate release profile. Conversely, F2 (blue) (R(+)CS(+)) demonstrated a longed release of vitamins A and D. with only 60% dissolved after 45 minutes

Figure 10 Absorption of gummies

3 Result and Discussion

3.1 Chemical Test

To ensure the presence of bioactive constituents in the polyherbal gummies, various preliminary phytochemical (chemical) tests had been conducted on the herbal extracts incorporated into the formulation. These tests help confirm the presence of key therapeutic components such as alkaloids, flavonoids, tannins, saponins, glycosides, steroids, terpenoids, and phenolic compounds. Standard methods like Mayer's and Wagner's tests for alkaloids, Shinoda test for flavonoids, Ferric chloride test for phenols, and foam test for saponins had been performed. The presence of these constituents contributes significantly to the antioxidant, anti-inflammatory, and neuroprotective effects of the gummies.

Table 2 Chemical test for Alkaloids

Test	**Observation**
Mayor's test	+ve
Hager's test	+ve
Dragendroff 's test	+ve
Wagner's test	**+ve**

Table 3 Chemical test for Phenols

Test	Observation
Litmus test	+ve
Ferric Chloride test	+ve
Bromine water test	+ve

Table 4 Chemical test for Flavonoids

Test	Observation
Shinoda test	+ve

Table 5 Chemical test for Saponins

Test	Observation
Foam test	+ve

Chemical Test of Plant Extract

3.2 Physical test of Gummies Result

Table 6 Physical test of Gummies

Sr.no	Parameter	F1	F2	F3	F4
1	Appearance	slightly glossy surface, and natural brownish-yellow to light green colour	slightly glossy surface, and natural brownish-yellow to light green colour	slightly glossy surface, and natural brownish-yellow to light green colour	slightly glossy surface, and natural brownish-yellow to light green colour
2	Texture	easy to bite without being sticky or brittle	easy to bite without being sticky or brittle	easy to bite without being sticky or brittle	easy to bite without being sticky or brittle
	A. Hardness				
	B. Firmness	agar or gelatin provided good firmness and elasticity	agar or gelatin provided good firmness and elasticity	agar or gelatin provided good firmness and elasticity	agar or gelatin provided good firmness and elasticity
	Softness	soft, chewy, and resilient	soft, chewy, and resilient	soft, chewy, and resilient	soft, chewy, and resilient
3	Odour	mild, pleasant herbal aroma	mild, pleasant herbal aroma	mild, pleasant herbal aroma	mild, pleasant herbal aroma
4	pH Value	4.6	4.8	4.5	4.7
5	Taste	Sweet, slightly bitter, herbal with refreshing aftertaste	Sweet, slightly bitter, herbal with refreshing aftertaste	Sweet, slightly bitter, herbal with refreshing aftertaste	Sweet, slightly bitter, herbal with refreshing aftertaste
6	Mouthfeel	smooth, soft, and chewy mouth feel with a pleasant consistency	smooth, soft, and chewy mouth feel with a pleasant consistency	smooth, soft, and chewy mouth feel with a pleasant consistency	smooth, soft, and chewy mouth feel with a pleasant consistency
7	Weight variation	1.40gm	1.52gm	1.99gm	2.29gm

	(Average Weight)				
8	Stickiness	Non-sticky	Non-sticky	Non-sticky	Sticky

3.3 Solubility test

Table 7 Solubility test of Gummies

Sr. no	Solvent	Solubility	Time to Dissolve	Impact of Temperature	Impact of pH
1	Water	Moderate to high	30-120 min	Increase Solubility	Neutral to Basic
2	Ethanol	Poor to None	No significant change	Slight Swelling	Minimal
3	Stimulated Gastric Fluid	High	30-120 min	Increases Solubility	Acidic (pH 1.2)

3.4 Moisture content

Table 8 Moisture content of Gummies

Batches	Initial Weight (g)	Final Weight (g)	Moisture Content (%)
F1	2.00	1.85	7.5%
F2	2.00	1.80	10.0%
F3	2.00	1.82	8.5%
F4	2.00	1.78	11.0%

3.5 Stability study

The gummy preparation was found to be stable throughout the 3month study at room temperature and at (25 ± 2°C, 60% ± 5% RH).

4 Conclusion

The formulated polyherbal gummies containing Ashwagandha, Tulsi, Turmeric, and Guava leaves demonstrated promising antioxidant, anti-inflammatory, and neuroprotective properties. These effects suggest potential supportive benefits in managing Alzheimer's disease symptoms. The gummies showed acceptable physical, chemical, and microbial stability over time, making them a convenient and palatable delivery system for long-term use in neurodegenerative conditions. The phytochemical screening confirmed the presence of essential bioactive compounds. Evaluation studies, including DPPH, FRAP, and NO scavenging assays, provided scientific evidence of antioxidant efficacy. Among the batches, [mention best batch, e.g., Batch B3] showed optimal performance in terms of formulation quality and biological activity. The study concludes that polyherbal gummies are an effective, convenient, and patient-friendly approach to deliver herbal actives for cognitive health. Further in vivo studies and clinical validation are recommended to establish long-term therapeutic benefits.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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