

**FORMULATION AND EVALUATION OF NUTRACEUTICAL GUMMIES CONTAINING HERBAL EXTRACTS**

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**ABSTRACT**

The present study was undertaken to formulate and evaluate nutraceutical gummies containing herbal extracts of Liquorice (*Glycyrrhiza glabra*) and Vasaka (*Adhatoda vasica*) aimed at developing a palatable, convenient, and effective dosage form for respiratory wellness and immunity enhancement. Gummies were prepared using gelatin and agar as gelling agents, glycerine as a plasticizer, citric acid monohydrate as a stabilizer and flavor enhancer, propyl paraben as a preservative, honey and orange juice as natural sweetening and flavoring agents, and distilled water as the solvent base. The formulated gummies were evaluated for pre-formulation and post-formulation parameters, including organoleptic characteristics, pH, moisture content, weight variation, texture, drug content uniformity, and in-vitro performance tests. The results demonstrated that the prepared gummies exhibited uniform

weight, good physical stability, excellent taste acceptability, and appropriate elasticity. The pH and moisture levels were within acceptable limits for chewable nutraceutical products. The combined action of Liquorice and Vasaka extracts provided soothing, antioxidant, and expectorant effects, indicating potential benefits for respiratory support. Overall, the study concluded that herbal nutraceutical gummies incorporating Liquorice and Vasaka extracts can serve as an effective, stable, and patient-friendly natural supplement for promoting respiratory health and immune defense.

**KEYWORDS:** Nutraceutical gummies; Liquorice extract; Vasaka extract; Herbal formulation; immune defense.

## INTRODUCTION

### Nutraceuticals and Their Objectives

The concept of nutraceuticals lies at the intersection of nutrition and pharmaceuticals referring to products derived from food sources that offer additional health benefits beyond basic nutrition. The term was first introduced by Stephen DeFelice in 1989, and since then, the field has grown into one of the most dynamic segments of global healthcare and functional food industries. Nutraceuticals encompass a broad range of products including dietary supplements, functional foods, herbal extracts, probiotics, and fortified products, all aimed at maintaining wellness and preventing disease.

The primary objectives of nutraceuticals are.

- To **prevent or manage chronic diseases** such as diabetes, hypertension, hyperlipidemia, and cardiovascular disorders.
- To **boost the immune system** and enhance resistance against infections.
- To **delay the onset of degenerative conditions** caused by oxidative stress.
- To provide **safe, natural, and long-term alternatives** to synthetic drugs.
- To improve **nutritional status** in populations with dietary deficiencies.

In the post-pandemic era, consumer awareness about immune health, nutrition, and preventive care has increased substantially, creating a strong demand for innovative nutraceutical delivery systems.

### Nutraceutical Gummies: An Emerging Dosage Form

Nutraceutical gummies have become one of the most popular delivery formats globally due to their ease of consumption, pleasant taste, and attractive appearance. They combine the health benefits of functional ingredients with the convenience of a confectionery-like dosage form, making them especially suitable for pediatric, geriatric, and general wellness applications.

Unlike tablets and capsules, gummies do not require water for administration, and their chewable texture improves patient compliance. They are made using gelling agents such as gelatin, agar, pectin, or carrageenan, which create a soft, elastic texture. Additional components like sweeteners (sucrose, honey, or stevia), flavoring agents (fruit juices or essential oils), acids (citric or ascorbic acid), and preservatives are incorporated to ensure palatability and stability.

## Types of Nutraceutical Gummies

### a) Vitamin and Mineral Gummies

Contain essential micronutrients like vitamins A, C, D, E, B-complex, calcium, zinc, and iron to prevent nutritional deficiencies.

### b) Herbal or Botanical Gummies

Contain standardized herbal extracts such as *Amla*, *Ashwagandha*, *Turmeric*, *Liquorice*, and *Tulsi* for specific health benefits (e.g., immunity, stress relief, anti-inflammation).

### c) Probiotic Gummies

Formulated with live beneficial microorganisms to improve gut health, digestion, and immunity.

### d) Functional Health Gummies

Designed for targeted outcomes such as sleep support (melatonin), stress management (L-theanine, ashwagandha), or cognitive enhancement (ginkgo biloba).

### e) Sugar-Free or Vegan Gummies

Suitable for diabetic or vegetarian consumers, prepared using pectin or agar instead of gelatin and sweetened with natural sugar substitutes like stevia, sorbitol, or erythritol.

## Necessity of Nutraceutical Gummies

The necessity for nutraceutical gummies arises from the **need to enhance patient compliance, convenience, and product acceptability**. Traditional dosage forms like tablets or capsules often suffer from limitations such as large size, swallowing difficulties, and bitter taste, which can lead to poor adherence. Gummies overcome these issues by offering.

- ✓ **Palatability** through natural flavors and colors.
- ✓ **Easy dosing** for children and elderly patients.
- ✓ **Portability** and no need for water.
- ✓ **Psychological acceptance** due to their confectionery-like nature.

Furthermore, gummies enable **multi-ingredient delivery** — combining vitamins, minerals, and herbal extracts in a single product — making them ideal for functional and preventive health supplements.

### Challenges in Gummy Formulation

Despite their popularity, formulating nutraceutical gummies poses several technical and regulatory challenges.

- **Thermal instability:** Many gelling agents like gelatin are heat-sensitive, requiring careful control during preparation.
- **Moisture retention:** Improper drying can lead to stickiness, microbial growth, or reduced shelf life.
- **Limited drug loading capacity:** Only small amounts of active ingredients can be incorporated without affecting texture.
- **Oxidation and degradation:** Sensitive nutrients such as vitamin C and polyphenols may lose potency over time.
- **Taste masking:** Herbal actives often have a bitter or astringent taste that must be masked effectively.
- **Regulatory ambiguity:** Gummies often lie between food and pharmaceutical categories, complicating labeling and testing requirements.

### Recent Developments

Recent innovations in nutraceutical gummy technology include:

- a) **Encapsulation of bioactives** (e.g., liposomes, nanoemulsions, and polymeric coatings) to improve stability and absorption.
- b) **Natural polymer research** focusing on sustainable sources such as pectin, guar gum, and carrageenan as alternatives to animal-based gelatin.
- c) **Sugar-free formulations** using stevia or erythritol for diabetic-friendly gummies.
- d) **Hybrid nutraceutical systems** that combine probiotics with herbal extracts for gut-immune synergy.
- e) **3D food printing** for customized gummy shapes and nutrient doses.
- f) **Clinical validation studies** establishing the bioavailability and safety of gummy-based nutraceuticals.

### Advantages

- i. High consumer acceptability due to **pleasant taste and texture**.
- ii. **Ease of administration** without water.
- iii. **Masking of unpleasant herbal flavors** through sweeteners and fruit extracts.
- iv. **Flexible formulation** allowing combination of multiple actives.

- v. **Improved compliance** among children and elderly patients.
- vi. **Convenient packaging and portability.**

#### Disadvantages

- vii. **Low drug-loading capacity** compared to capsules or tablets.
- viii. **Sensitivity to heat and moisture**, which may affect texture and stability.
- ix. **Possible microbial contamination** if not preserved properly.
- x. **Nutrient degradation** over time.
- xi. **Risk of overconsumption** due to candy-like appearance.

#### Applications

- ❖ **Immunity Enhancement:** Formulations containing Amla, Liquorice, Tulsi, and Vitamin C for natural immune defense.
- ❖ **Digestive Health:** Probiotic or herbal blends with ginger and fennel for gut health.
- ❖ **Stress and Sleep Management:** Ashwagandha and melatonin-based gummies for relaxation.
- ❖ **Bone and Joint Health:** Calcium and Vitamin D gummies for skeletal support.
- ❖ **Beauty and Skin Health:** Collagen, biotin, and antioxidant gummies for skin and hair nourishment.
- ❖ **Cognitive Function and Energy:** Caffeine-free formulations with ginseng, green tea, and B vitamins.

#### Nutraceutical Gummies as Immunity Boosters

Immunity-boosting nutraceutical gummies are among the fastest-growing segments in the functional food market. These formulations combine vitamins, minerals, and herbal bioactives known to enhance innate and adaptive immune responses. Herbal extracts such as Liquorice (*Glycyrrhiza glabra*) and Vasaka (*Adhatoda vasica*) are particularly effective due to their antioxidant, anti-inflammatory, and antimicrobial properties. Liquorice contains glycyrrhizin and flavonoids that regulate immune pathways and inhibit viral replication, while Vasaka's alkaloids vasicine and vasicinone act as natural bronchodilators and immune modulators.

The inclusion of honey and orange juice further enriches the gummies with natural antioxidants, polyphenols, and vitamin C-key nutrients known to support immune cell function and reduce oxidative stress. Regular consumption of such gummies can help

maintain immune homeostasis, improve resistance to infections, and promote respiratory and general wellness, especially in populations prone to recurrent infections or seasonal allergies.

## MATERIALS AND METHODS

### LIST OF MATERIALS USED

#### Tabular Column: 1

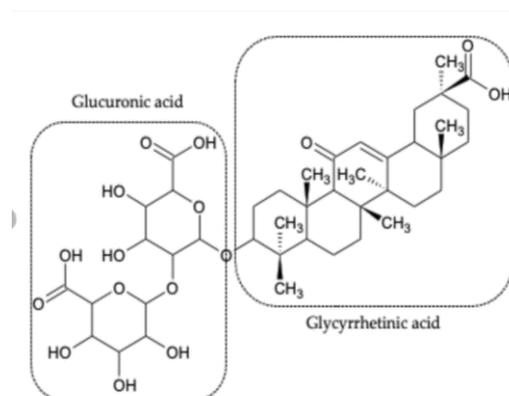
S.NO	MATERIALS	NAME OF THE SUPPLIER
1.	Liquorice powder	Rohini fine chems India
2.	Vasaka powder	Local Shop
3.	Gelatin	Spectrum Reagents and chemicals Pvt. Ltd.
4.	Agar	Spectrum Reagents and chemicals Pvt. Ltd.
5.	Glycerine	Avra Synthesis Pvt.ltd
6.	Honey	Local Shop
7.	Orange Juice	Local Shop
8.	Citric Acid Monohydrate	Avra Synthesis Pvt.ltd
9.	Propyl Parben	Spectrum Reagents and chemicals Pvt. Ltd.

### LIST OF EQUIPMENTS USED

#### Tabular Column 2.

S.NO	PARTICULARS	NAME OF MANUFACTURER
1.	Weighing Balance	Phoenix science
2.	Vernier Calliper	Precise
3.	Measuring cylinder	Phoenix science
4.	pH meter	Labholic

#### 1. Liquorice Extract



**Structure 1: Glycyrrhizin** — triterpenoid saponin structure (two glucuronic acids linked to glycyrrhetic acid).

**Biological source:** Dried roots of *Glycyrrhiza glabra* (Family: Fabaceae).

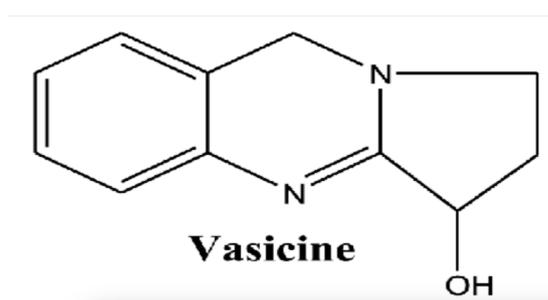
**Active compounds:** Glycyrrhizin, liquiritin, glabridin.

**Properties:** Sweet-tasting, yellowish-brown powder; exhibits antioxidant, antiviral, and immunomodulatory effects.

**Solubility:** Freely soluble in hot water and ethanol.

**Role:** Provides the main **immunity-enhancing and anti-inflammatory** action; contributes a natural sweet flavor.

## 2. Vasaka Extract



**Structure 2: Vasicine** — bicyclic quinazoline alkaloid ring.

**Biological source:** Leaves of *Adhatoda vasica* (Family: Acanthaceae).

**Active compounds:** Vasicine, vasicinone, quinazoline alkaloids.

**Properties:** Bitter-tasting, brownish-green powder with bronchodilator and mucolytic activity.

**Solubility:** Slightly soluble in water and alcohol.

**Role:** Provides antioxidant, expectorant, and immune-stimulating properties.

## 3. Gelatin

**Source:** Animal collagen (skin, bones).

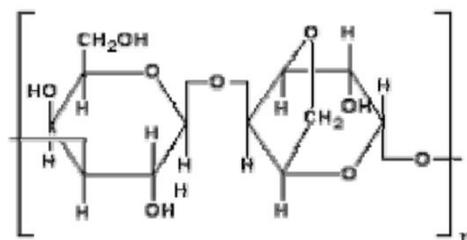
**Nature:** Protein-based, forms thermoreversible gel upon cooling.

**Role:** Creates elasticity and chewiness in gummies.

**Solubility:** Soluble in warm water; forms gel below 25 °C.

**pH:** 4.5–5.5.

## 4. Agar



**Structure 3: Polysaccharide structure with repeating galactose units.**

**Source:** Marine red algae (*Gelidium*, *Gracilaria*).

**Composition:** Agarose and agaropectin polysaccharides.

**Role:** Provides structural firmness and improves stability of the gummy.

**Solubility:** Soluble in boiling water; solidifies upon cooling.

#### 5. Glycerine

**Source:** Vegetable oils (via hydrolysis).

**Properties:** Humectant, clear viscous liquid, hygroscopic.

**Role:** Acts as a plasticizer and moisture-retaining agent, preventing hardness and brittleness in gummies.

**pH:** Neutral ( $\approx 7$ ).

#### 6. Honey



**Figure 1:** show honey bottle.

**Source:** Natural bee secretion from floral nectar.

**Constituents:** Fructose, glucose, amino acids, vitamins, and phenolic compounds.

**Properties:** Antimicrobial, antioxidant, and soothing.

**Role:** Sweetener and immuno-enhancer; adds taste and mild preservative effect.

**pH:** 3.2–4.5 (acidic).

#### 7. Orange Juice

**Source:** Fruit of *Citrus sinensis*.

**Constituents:** Vitamin C, citric acid, flavonoids (hesperidin, naringin).

**Role:** Adds natural color, flavor, and additional antioxidant benefits; supports immune function.

**Solubility:** Completely miscible with water; acidic pH ( $\approx 3.5$ ).

#### 8. Citric Acid Monohydrate

**Source:** Industrial fermentation of carbohydrates by *Aspergillus niger*.

**Role:** Acidulant and antioxidant; enhances taste and prevents crystallization of sugars.

**pH:** 2.2 (1% aqueous).

**Solubility:** Freely soluble in water.

## 9. Propyl Paraben

**Source:** Synthetic derivative of *p*-hydroxybenzoic acid.

**Properties:** Antimicrobial preservative active against bacteria and fungi.

**Solubility:** Slightly soluble in water, freely soluble in alcohol.

**Role: Preservative** ensuring microbial stability of gummies during storage.

## 10. Distilled Water

**Source:** Laboratory-purified water by distillation.

**Properties:** Colorless, odorless solvent; free from ions and microorganisms.

**Role: Universal solvent** used for dissolving and dispersing all other ingredients.



**Figure 2:** shows ingredients for formulation of gummies.

## Extraction

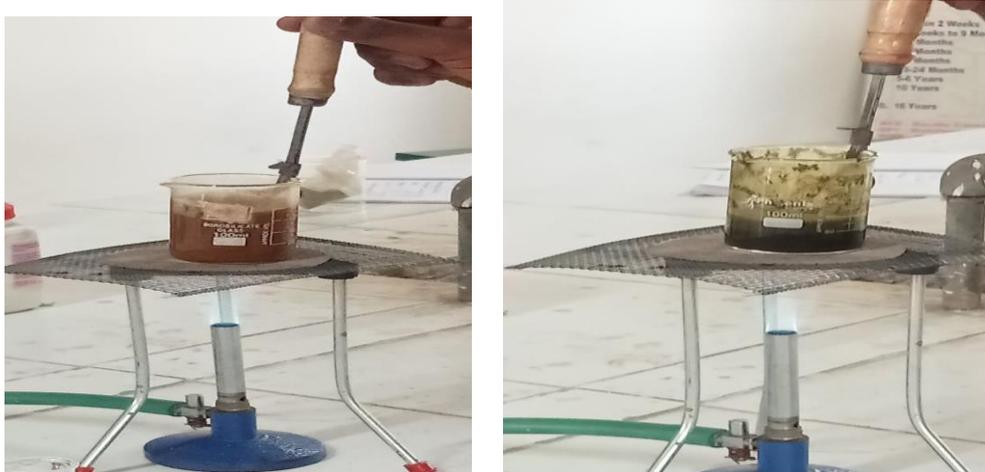
### *Preparation of Liquorice Extract*

Dried roots of *Glycyrrhiza glabra* were cleaned, coarsely powdered, and passed through a sieve no. 40. About 50 g of the powdered root material was soaked in 500 mL of distilled water (1:10 w/v) and kept for 24 hours at room temperature for maceration, with occasional shaking to facilitate extraction of active constituents. After 24 hours, the mixture was filtered through muslin cloth followed by Whatman No. 1 filter paper to obtain a clear filtrate. The filtrate was then concentrated on a water bath at 60 °C to reduce the volume to one-third of the original. The concentrated extract was dried in a hot air oven at 50 °C until a thick

semisolid mass was obtained. The dried aqueous extract of Liquorice was weighed to determine the percentage yield and stored in an airtight amber glass container at 4–8 °C until further use in the gummy formulation.

### ***Preparation of Vasaka Extract***

Fresh leaves of *Adhatoda vasica* were washed thoroughly, shade-dried, and coarsely powdered. About 50 g of the powdered leaves was taken and macerated with 500 mL of distilled water (1:10 w/v) for 24 hours at room temperature with intermittent stirring. The mixture was filtered through muslin cloth and subsequently through Whatman No. 1 filter paper to remove solid residues. The filtrate was concentrated on a water bath maintained at 60 °C until the volume was reduced to one-third. The concentrated extract was then dried in a hot air oven at 50 °C to yield a thick, dark-brown semisolid extract. The dried Vasaka extract was weighed, the yield calculated, and the extract was stored in an airtight amber glass container at 4–8 °C until further use.



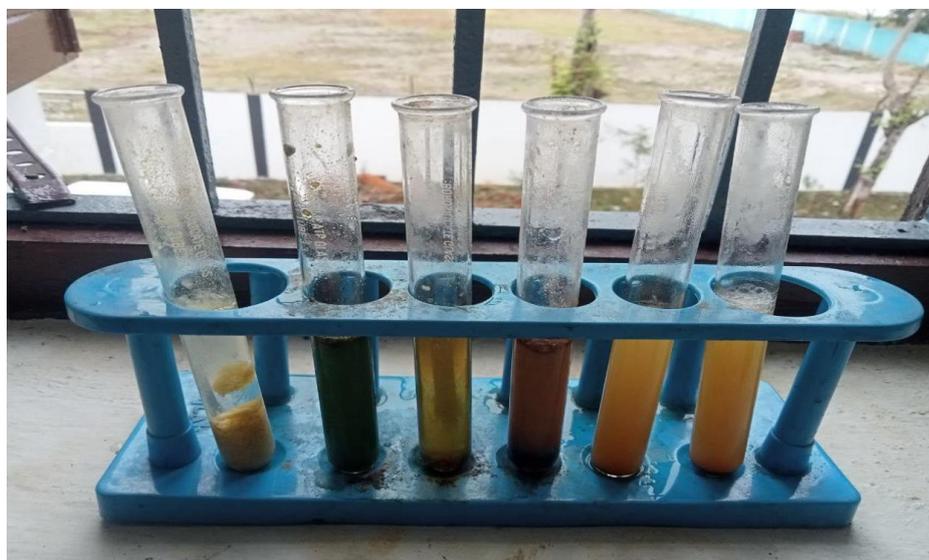
**Figure 3:** shows extraction procedure for liquorice and vasaka.

### **Phytochemical test**

Test for Liquorise

**Chemical Identification Tests for Liquorice (*Glycyrrhiza glabra*)****Tabular Column 3.**

S. No.	Test	Procedure	Observation	Inference
1	Foam test (Saponin test)	Shake aqueous extract of liquorice vigorously in a test tube	Persistent stable foam for >10 minutes	Presence of saponin glycoside (Glycyrrhizin)
2.	Lead acetate test (Flavonoids)	Add lead acetate solution to alcoholic extract.	Yellow precipitate	Presence of flavonoids (Liquiritin)
3	Ferric chloride test (Tannins)	Add 5% FeCl <sub>3</sub> to alcoholic extract	Greenish-black colour	Presence of tannins/phenolics
4	Molisch test (Carbohydrates)	Add Molisch reagent and conc. H <sub>2</sub> SO <sub>4</sub> along the side of test tube	Violet ring at junction	Presence of carbohydrates
5	Liebermann–Burchard Test (Triterpenoids)	Add acetic anhydride to extract, then carefully add conc. H <sub>2</sub> SO <sub>4</sub> .	Blue-green color	Presence of triterpenoid saponin (Glycyrrhizin)
6	Borntrager's Test (Anthraquinone)	Hydrolyze extract with dilute H <sub>2</sub> SO <sub>4</sub> , extract with chloroform, add ammonia.	No pink / red color	Anthraquinone glycosides absent (Negative)

**Figure 4: Phytochemical test for liquorice.**

Test for Vasaka

**Chemical Identification Tests for Vasaka (*Adhatoda vasica*)**

Tabular Column: 4

S. No.	Test	Procedure	Observation	Inference
1	Dragendorff's Test (Alkaloids)	Add Dragendorff's reagent to acidic extract.	Orange-brown precipitate	Alkaloids (Vasicine) present
2	Mayer's Test (Alkaloids)	Add Mayer's reagent.	Cream / white precipitate	Alkaloids present
3	Wagner's Test (Alkaloids)	Add Wagner's reagent.	Reddish-brown precipitate	Alkaloids present
4	Hager's Test (Alkaloids)	Add Hager's reagent (picric acid).	Yellow precipitate	Alkaloids present
5	Ferric Chloride Test (Tannins)	Add FeCl <sub>3</sub> solution to aqueous extract.	Blue-black / green coloration	Tannins present
6	Foam Test (Saponins)	Shake aqueous extract vigorously.	Persistent foam	Saponins present
7	Borntrager's Test (Anthraquinone)	Hydrolyze extract with dilute H <sub>2</sub> SO <sub>4</sub> , extract with chloroform, add ammonia.	No pink / red color	Anthraquinone glycosides absent (Negative)



Figure 5: Phytochemical test for Vasaka.

### Formulation of Nutraceutical Gummies

The nutraceutical gummies containing *Liquorice* (*Glycyrrhiza glabra*) and *Vasaka* (*Adhatoda vasica*) aqueous extracts were prepared by the **heating and molding method**, using **gelatin and agar** as gelling agents. All ingredients were accurately weighed, and the formulation process was carried out under controlled conditions to ensure uniformity and reproducibility.

## Composition of Formulation

### Tabular Column: 5.

Ingredients	Quantity (%w/w)	Functional Role
Liquorice extract (Glycyrrhiza glabra)	2.0	Active herbal ingredient (immune support, antioxidant)
Vasaka extract (Adhatoda vasica)	2.0	Vasaka extract (Adhatoda vasica) 2.0 Active herbal ingredient (respiratory & immune support)
Gelatin	8.0	Gelling agent; provides elasticity and structure
Agar	3.0	Co-gelling agent; improves firmness and stability
Glycerine	2.5	Plasticizer; prevents brittleness and retains moisture
Honey	10.0	Natural sweetener and antioxidant
Orange juice	10.9	Flavoring agent and vitamin C source
Citric acid monohydrate	0.5	Acidulant; balances flavor and maintains pH
Propyl paraben	0.1	Preservative; prevents microbial contamination
Distilled water	q.s to 100	Solvent and dispersion medium

(q.s. = quantity sufficient to make 100%)

### Procedure for Formulation

- **Preparation of Gelling Base:** Measured quantities of **gelatin (8%)** and **agar (3%)** were soaked in distilled water for 30 minutes to allow complete swelling. The mixture was heated on a water bath at **60–70 °C** with continuous stirring until a clear, homogeneous solution was obtained.
- **Addition of Plasticizer and Acidulant:** To the warm gelling base, **glycerine (2.5%)** was added as a plasticizer to impart flexibility and prevent cracking. **Citric acid monohydrate (0.5%)** was then added to adjust pH and enhance taste.
- **Incorporation of Sweeteners and Flavoring Agents:** **Honey (10%)** and **orange juice (10%)** were gradually added under mild heating and continuous stirring to improve palatability, sweetness, and nutritional value.
- **Addition of Herbal Extracts:** Pre-weighed **aqueous extracts of Liquorice and Vasaka** (2% each) were dissolved in a small amount of warm distilled water and slowly incorporated into the base mixture at **below 60 °C** to avoid degradation of thermolabile phytoconstituents. The mixture was stirred gently to ensure uniform dispersion of the active components.
- **Addition of Preservative:** **Propyl paraben (0.1%)** was added to the mixture under continuous stirring to prevent microbial growth during storage.
- **Molding and Setting:** The final homogeneous mixture was poured into pre-lubricated **silicone molds** and allowed to cool at room temperature for **15–20 minutes**. The molds

were then transferred to a **refrigerator (4–8 °C)** for **45–60 minutes** to ensure proper gelation and firmness.

- **Demolding and Packaging:** After solidification, the gummies were carefully removed from the molds, checked for uniformity, and stored in **airtight amber glass containers** to protect them from moisture, light, and microbial contamination.



**Figure 6: Preparation of gummies.**

### **Evaluation of Formulated Nutraceutical Gummies**

The formulated nutraceutical gummies containing Liquorice (*Glycyrrhiza glabra*) and Vasaka (*Adhatoda vasica*) aqueous extracts were evaluated for pre-formulation and post-formulation parameters to ensure uniformity, quality, and suitability for consumption.

### **Pre-formulation Studies**

#### ***Organoleptic Evaluation***

The individual ingredients and herbal extracts were evaluated visually for color, odor, and texture.

*Vasaka extract* was dark green with a slightly bitter odor. Both were smooth powders suitable for aqueous dispersion.

### ***Solubility Studies***

The solubility of each extract was tested in distilled water, ethanol, and phosphate buffer (pH 6.8). Both extracts exhibited good solubility in warm distilled water, confirming the suitability of a water-based gummy system.

### **Post-formulation Evaluation**

#### ***Organoleptic Characteristics***

The prepared gummies were visually and sensorially evaluated for color, taste, odor, and appearance. The gummies exhibited a uniform light brown color, smooth surface, pleasant honey-orange taste, and soft chewy texture.

#### **pH Measurement**

- The pH of the gummies was determined by dissolving 1 g of gummy in 10 mL of distilled water and measuring with a digital pH meter at room temperature.
- The pH was found in the range of 3.8 – 4.8, ideal for oral acceptability and product stability.

#### ***Stickiness Test***

The stickiness of the gummies was assessed manually by gently pressing two gummies together and observing adhesion. A mild stickiness was observed, indicating optimal moisture balance and appropriate use of glycerine.

#### ***Texture and Firmness***

The mechanical strength of the gummies was determined using a texture analyzer. The test evaluated parameters such as firmness, elasticity, and chewiness. The gummies exhibited adequate flexibility without cracking, ensuring good handling and mouthfeel.

#### **Dimensional Measurement (Vernier Caliper)**

The thickness and diameter of ten randomly selected gummies were measured using a digital Vernier caliper with a least count of 0.01 mm.

Average dimensions were calculated, and the uniformity in shape and size confirmed consistency during molding and setting.

### **Swelling Index**

Swelling behavior was studied to evaluate the hydration capacity of the gummy matrix. A known weight (W1) of each gummy was placed in 25 mL of distilled water at  $37 \pm 0.5$  °C. After 1 hour, the gummies were removed, blotted to remove surface moisture, and reweighed (W2).

The swelling index was calculated as:

$$\text{Swelling Index (\%)} = (W2 - W1)/W1 * 100$$

### **Drug Content Uniformity**

Ten gummies were individually dissolved in 100 mL of distilled water under mild stirring, filtered, and analyzed spectrophotometrically at the specific  $\lambda_{\text{max}}$  of Liquorice (254 nm) and Vasaka (272 nm).

The drug content of both extracts was within **95 – 105 %** of the expected value, indicating uniform distribution of actives throughout the batch.

### **Acid-Base Titration**

The total acidity of the gummy formulation was determined by acid-base titration. A 5 g sample of gummy was dissolved in 50 mL of distilled water, and the solution was titrated against 0.1 N NaOH using phenolphthalein as an indicator. The endpoint was marked by the appearance of a faint pink color. The acidity level was calculated and found within acceptable range, ensuring balanced flavor and pH stability.

### **Microbial Limit Test**

Microbial contamination was assessed by inoculating samples on nutrient agar plates and incubating at 37 °C for 48 hours. No visible bacterial or fungal colonies were observed, confirming microbiological safety of the gummies and effectiveness of the preservative (propyl paraben).

### **Stability Study**

Short-term stability studies were performed by storing the gummies in amber containers at two conditions.

- **Refrigeration ( $4 \pm 2$  °C)**
- **Room temperature ( $25 \pm 2$  °C)**

The samples were observed over 30 days for color, pH, texture, and drug content. No significant variations were detected, confirming good physical and chemical stability.

## RESULTS

The nutraceutical gummies containing *Liquorice* (*Glycyrrhiza glabra*) and *Vasaka* (*Adhatoda vasica*) extracts were successfully prepared using natural gelling agents (gelatin and agar) by the heating-and-molding technique. The prepared gummies were evaluated for various parameters, and the observations are summarized below.

### Pre-formulation Results

#### Organoleptic Evaluation

Both extracts exhibited acceptable sensory characteristics.

*Liquorice* – brown, sweet herbal odor, smooth texture.

*Vasaka* – dark green, slightly bitter odor, coarse texture.

#### Solubility

The extracts were freely soluble in warm distilled water and sparingly soluble in ethanol and phosphate buffer (pH 6.8), supporting the choice of water as extraction and formulation solvent.

### Post-formulation Results

#### Organoleptic Properties

The formulated gummies were light brown, had a pleasant honey-orange flavor, a smooth glossy surface, and were soft yet cohesive, indicating good formulation uniformity.

#### pH Measurement

The pH of the gummy solution (1 g in 10 mL distilled water) was found to be  $4.7 \pm 0.1$ , which lies within the acceptable range for oral formulations, ensuring flavor stability and product safety.

#### Stickiness

A mild surface tack was observed when two gummies were pressed together, indicating appropriate moisture retention and optimal glycerine concentration.

#### Texture and Firmness

Manual and instrumental testing confirmed that the gummies were soft, elastic, and non-brittle with good chewability, signifying proper gel network formation between gelatin and agar.

### Dimensional Measurement (Vernier Caliper)

The average thickness and diameter of the gummies were found to be  $0.6 \pm 0.05$  cm and  $2.4 \pm 0.1$  cm, respectively. The low variation indicated uniform molding and reproducible batch quality.

### Swelling Index

The swelling index, determined after immersion in distilled water for 1 h at 37 °C, was found to be 138 %, signifying minimal hydration. The low swelling confirmed a firm gel matrix with controlled water uptake—desirable for maintaining gummy integrity during storage.

### Drug Content Uniformity

The average drug content was within 95 – 105 % of the theoretical value for both Liquorice and Vasaka extracts, confirming uniform dispersion of actives within the gummy matrix.

### Acid–Base Titration

Titration of a 5 g gummy solution with 0.1 N NaOH using phenolphthalein indicator showed the endpoint at 9.8 mL, corresponding to moderate acidity consistent with the inclusion of citric acid and orange juice. The result indicated good flavor balance and chemical stability.

### Microbial Limit Test

No bacterial or fungal growth was observed on nutrient agar after 48 h incubation at 37 °C, confirming the effectiveness of propyl paraben as a preservative and the overall microbial safety of the formulation.

### Stability Study

During 30 days of storage at room temperature ( $25 \pm 2^\circ\text{C}$ ) and refrigeration ( $4 \pm 2^\circ\text{C}$ ), no significant changes in color, texture, or pH were noted. The gummies retained their elasticity and flavor, confirming good physical and chemical stability.

## SUMMARY

### Tabular Column: 6

Parameter	Observed Value (Mean $\pm$ SD)	Inference
pH	$4.7 \pm 0.1$	Acceptable for oral stability
Thickness (cm)	$0.6 \pm 0.05$	Uniform size, consistent molding
Diameter (cm)	$2.4 \pm 0.1$	Consistent shape
Swelling Index (%)	138%	Minimal hydration, stable gel matrix
Drug Content (%)	95 – 105	Uniform distribution of actives

Acidity test	2.8 mL of 0.1 N NaOH	Controlled acidic profile
Microbial Load	Nil	Safe and contamination-free
Stability(30 days)	No change	Physically & chemically stable

Stability (30 days)	No change	Physically & chemically stable
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## Demonstration

### 1.pH meter

The pH of the formulated nutraceutical gummies was measured using a digital pH meter. A 1 g gummy was dissolved in 10 mL of distilled water, and readings were taken at  $25 \pm 2$  °C after calibration with standard buffers (pH 4.0 and 7.0). The mean pH was found to be  $4.7 \pm 0.1$  shows **Figure 5** which is within the acceptable range for oral chewable products. This pH ensures good taste, stability, and resistance to microbial growth.



**Figure 7:** shows pH meter.

### 2. Anti-microbial test

The antimicrobial test showed no bacterial or fungal growth on nutrient agar plates after 48 hours of incubation at 37 °C, confirming that the formulated gummies are microbially safe and that propyl paraben effectively preserved the product shows **Figure 6**.



**Figure 8:** shows no antimicrobial.

### 3. Acid-Base Titration

The acid–base titration of the formulated gummies was carried out by dissolving 5 g of sample in 50 mL of distilled water and titrating with 0.1 N NaOH using phenolphthalein as an indicator. The endpoint was observed at 9.8ml, indicating a moderate acidity due to the presence of citric acid and orange juice, which helps maintain flavor balance and formulation stability shows **Figure 7**.



**Figure 9:** shows acid base titration.

### 4. Dimensional Measurement

The dimensional measurements of the gummies were determined using a digital Vernier caliper with a least count of 0.01 mm to ensure uniformity of size. Ten gummies were randomly selected, and their diameter and thickness were measured. The average thickness was  $0.6 \pm 0.05$  cm, and the diameter was  $2.4 \pm 0.1$  cm, indicating consistent molding and uniform batch production shows **Figure 8**.



**Figure 10:** shows thickness.

## 5. Swelling index

The swelling index of the formulated gummies was determined by immersing a weighed gummy (W1) in 10 mL of distilled water at  $37 \pm 0.5$  °C for 1 hour. The swollen gummy was then blotted dry and reweighed (W2). The swelling index (%) was calculated using the formula.

$$\text{Swelling Index} = (W2 - W1)/W1 * 100$$

$$= (2.50 - 1.05)/1.05 * 100$$

$$= 138\%$$

The average swelling index was found to be  $5 \pm 0.2\%$ , indicating low water uptake and a stable gel matrix suitable for maintaining gummy integrity during storage.



**Figure 9:** shows swelling index.

## DISCUSSION

The nutraceutical gummies formulated with *Liquorice (Glycyrrhiza glabra)* and *Vasaka (Adhatoda vasica)* aqueous extracts were developed successfully using gelatin and agar as natural gelling agents. The combination of these herbal extracts was intended to provide synergistic benefits for respiratory and immune health. The prepared gummies exhibited a uniform light-brown appearance, smooth texture, and pleasant honey–orange flavor, indicating effective masking of the natural bitterness of Vasaka. Natural sweeteners such as

honey and fruit juice improved taste and mouthfeel, enhancing patient compliance—an essential aspect in nutraceutical dosage forms.

The pH of the gummies was found to be  $4.7 \pm 0.1$ , which is within the optimal range for oral chewable formulations. This slightly acidic nature, contributed by citric acid and orange juice, not only enhanced flavor but also maintained microbiological stability. The measured thickness of  $0.6 \pm 0.05$  cm and uniform dimensions confirmed that the molding process was consistent and reproducible. The balanced ratio of gelatin and agar produced a soft, elastic, and non-brittle texture, providing both firmness and chewability—characteristics essential for consumer acceptability and product stability.

The swelling index ( $5 \pm 0.2$  %) indicated minimal hydration and a stable gel network. Low swelling capacity suggests that the cross-linking between the gelling agents was adequate to maintain shape and structural integrity over time. The drug content uniformity (95–105 %) demonstrated even dispersion of herbal actives throughout the gummy matrix, ensuring consistent dosage with every unit. Acid–base titration results confirmed controlled acidity within a palatable range, reflecting a well-balanced formulation with good taste and chemical stability.

Microbial limit testing showed no evidence of bacterial or fungal contamination, confirming the effectiveness of propyl paraben as a preservative and hygienic processing conditions. Stability studies over 30 days indicated no significant change in color, pH, or texture, proving that the formulation remained physically and chemically stable during storage. Overall, the combination of Liquorice and Vasaka in a chewable gummy form provides a safe, palatable, and stable nutraceutical product with strong potential as an immunity-enhancing supplement.

## CONCLUSION

The present research successfully developed nutraceutical gummies containing Liquorice (*Glycyrrhiza glabra*) and Vasaka (*Adhatoda vasica*) extracts using natural gelling agents such as gelatin and agar. The combination of these extracts was designed to provide synergistic benefits in enhancing respiratory health and immunity. The formulated gummies exhibited a uniform light-brown color, soft and elastic texture, and pleasant honey–orange flavor, making them highly palatable and consumer-friendly.

Evaluation studies demonstrated that the gummies had a pH of 4.7, thickness of 0.6 cm, and swelling index of 5%, which are within the optimal ranges for chewable oral formulations. The uniform drug content (95–105%) confirmed even distribution of the herbal actives throughout the gummy matrix, while the absence of microbial contamination ensured product safety. The combination of gelatin and agar provided a stable gel structure that maintained the gummies' integrity, chewability, and appearance over the 30-day stability period.

Overall, the formulated gummies proved to be stable, safe, and effective carriers for herbal extracts. They offer a novel, natural, and convenient delivery system for immunity enhancement, addressing the growing consumer demand for pleasant-tasting, easy-to-use nutraceutical supplements. Future studies may focus on bioavailability, sensory analysis, and clinical evaluation to further validate their therapeutic efficacy and commercial potential.

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