Formulation and Characterization of Sugar-Free Polyherbal Immunity Boosting Granules

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ABSTRACT
The creation of simple, tasty, and health-conscious formulations of herbal supplements has been spurred by the growing demand for these products worldwide. The purpose of this study was to create and evaluate a combination of sugar-free polyherbal granules that would increase immunity. For their immunomodulatory qualities, a blend of five medicinal herbs was chosen: Ashwagandha (*Withania somnifera*), Liquorice (*Glycyrrhiza glabra*), Giloy *(Tinospora cordifolia)*, Shatavari *(Asparagus racemosus)*, and Brahmi *(Bacopa monnieri).* The fifth experiment was chosen based on the best organoleptic and physicochemical properties after six consecutive 10 g trial formulations were created. Sodium saccharin, mannitol, and stevia were among the natural and artificial sweeteners combined to create a sugar-free combination. The resulting formulation was flavorful, flowable, and had just the correct amount of moisture. The research suggests that the produced granules could be utilized as a natural, sugar-free immune-boosting supplement.

Keywords: Immunity booster, Immunomodulatory, Sugar-free granules, Brahmi, Stevia, Mannitol, Supplement

1.INTRODUCTION

In light of global health concerns, particularly the COVID-19 pandemic, there has been a lot of interest in bolstering the human immune system. The immune system serves as the body's natural defense against pathogens, which include bacteria, viruses, and other harmful organisms. It employs an intricate web of interdependent cells, tissues, and organs to recognize, neutralize, and eliminate foreign substances(1). Immunity can be broadly divided into two categories: innate immunity, which provides immediate, non-specific protection, and adaptive immunity, which is extremely specific and changes over time in response to antigen exposure. Although pharmacological interventions are essential for treating illnesses, the emphasis on preventative healthcare has raised interest in natural, plant-based immune modulators, especially in ancient systems like Ayurveda(2).

1.1 The Importance of Immunity in Human Health

In order to protect the body against infections, illnesses, and outside invaders, immunity is an essential physiological function. In order to preserve homeostasis and general health, it involves a complex network of cells, tissues, and metabolic pathways that cooperate. The two main components of the immune system—innate and adaptive immunity—each have unique functions(3). Adaptive immunity delivers long-term, antigen-specific protection through memory cells, whereas innate immunity offers a quick, non-specific defense mechanism. Refusing infections, controlling inflammation, mending wounds, and avoiding cancer all depend on a strong immune system. Nonetheless, a number of contemporary societal problems, including as age, stress, bad eating habits, environmental contaminants, and sedentary lifestyles, have impaired the immune system(4).

1.2 Herbal Approaches to Immune Enhancement

For ages, traditional medical systems, like Ayurveda, Traditional Chinese Medicine (TCM), and Unani medicine, have relied heavily on herbal treatment. By controlling cytokine synthesis, increasing phagocytic activity, promoting lymphocyte proliferation, and displaying antioxidant or anti-inflammatory properties, a variety of medicinal plants are known to modify immunological responses. Herbal immunomodulators are gaining popularity again because of their perceived safety, all-encompassing strategy, and capacity to target several pathways at once. In contrast to synthetic medications that frequently target specific mechanisms or have unfavorable side effects, herbal formulations provide a more gentle yet efficient way to strengthen the immune system, particularly when used prophylactically(5).

1.3 Polyherbalism: A Synergistic Strategy

Combining two or more plants into one preparation is known as a polyherbal formulation. The idea of synergism, which states that the combined therapeutic effect of herbs is higher than the sum of their separate effects, serves as the justification for polyherbalism. In addition to increasing effectiveness, this method balances the possible negative effects of specific herbs, providing a more comprehensive and well-rounded treatment(6). Polyherbal medicines are commonly used in Ayurveda to improve energy and restore doshic equilibrium. Pharmacologically speaking, combining herbs with anti-inflammatory, antioxidant, adaptogenic, and immunostimulatory qualities can greatly strengthen the immune system and lower the risk of disease[7].

1.4 The Need for Sugar-Free Herbal Formulation

In order to improve flavor and maintain the formulation, traditional herbal formulations frequently contain sugar or honey as base components. However, this presents serious challenges for patients with metabolic syndrome, diabetes, or obesity. For some people, sugar intake might worsen pre-existing metabolic abnormalities and cause insulin resistance and hyperglycemia. There is a growing need for sugar-free substitutes that are both pleasant and medicinal due to rising knowledge of lifestyle diseases and dietary limitations[8]. Herbal formulations serving this health-conscious demographic are made possible by the inclusion of safe, low-calorie sweeteners such as sodium saccharin and mannitol.

1.5 Selection of Herbs for the Study

The following five extensively studied immunomodulatory herbs were chosen for this study:

Brahmi (*Bacopa monnieri*)[9]: Traditionally used to improve memory, Brahmi's bacoside concentration gives it immunomodulatory and antioxidant qualities.

Shatavari (*Asparagus racemosus*)[10]: This immune-boosting and rejuvenating plant promotes humoral and cell-mediated immunity.

Giloy (*Tinospora cordifolia*)[11]: An established immune booster, it reduces inflammation and increases resistance to infections.

Liquourice (*Glycyrrhiza glabra*)[12]: This herb has antiviral, anti-inflammatory, and immuno-boosting properties since it is high in glycyrrhizin.

Ashwagandha (*Withania somnifera*)[13], is an adaptogen that boosts immunity and lessens immunological suppression brought on by stress.

Leukocyte function, oxidative stress reduction, immunological pathway (Th1/Th2) balance, and stress resilience are some of the complementing ways these herbs act.

1.7 Granules as a Dosage Form

Granules are multi-particulate systems that offer several advantages over conventional powders and tablets. They have better flow properties, reduced dusting, enhanced stability, and allow uniform dosing. Granules can also be reconstituted with water or consumed directly, making them suitable for children and elderly individuals[14].

Furthermore, their larger particle size compared to powders improves mouthfeel, and they can be flavored easily for better compliance.

Table 1. Immunity boosting plants and their properties

S.no	**Plant Name** (Botanical)	**Plant Part**	**Chemical Constituents**	**Uses**	**Reference**
1.	*Bacopa monnieri*	Leaves,Root Stems, Flowers	Bacosides, Alkaloids, Flavonoids, Phenolic compounds,	Anti-inflammatory, Antioxidant, Stress and anxiety reduction	9

			Essential oils		
2.	*Asparagus racemosus*	Tuberous Root ,	Asparagamine B, Isoquercitrin, Glycosides, Saponins, Quercetin	Anti-inflammatory, Anticancer, Antiviral, Ulcers	10
3.	*Tinospora cordifolia*	Stem, roots, leaves	Alkaloids, Clerodane diterpenoids, Sesquiterpenoids, Phenyl propanoids	Antipyretic, Anti-inflammatory, Antiosteoporotic, Antiobesity, Anticarcinogenic	11
4.	*Glycyrrhiza glabra*	Root, Leaves	Liquiritin**,** Glabridin, Scopoletin, Umbelliferone	Antimicrobial, Antioxidant, Antispasmodic, Anti-inflammatory	12
5.	*Withania somnifera*	Root, leaves	Withanolides, Alkaloids, Saponins, Flavonoids, Fatty Acids	Stress reduction, Boosting Energy and stamina, Improves sleep.	13

This study used five well-known herbs Brahmi, Shatavari, Giloy, Liquorice, and Ashwagandha to create and assess a sugar-free polyherbal granule mixture. The immunomodulatory, adaptogenic, and antioxidant qualities of these plants are well-known. Making a tasty, sugar-free, granulated supplement and evaluating its fundamental physicochemical properties were the goals.

2.Materials and Method

The following herbal powders were used:

- Brahmi (*Bacopa monnieri*)
- Shatavari (*Asparagus racemosus*)
- Giloy (*Tinospora cordifolia*)
- Liquorice (*Glycyrrhiza glabra*)
- Ashwagandha (*Withania somnifera*)

Excipients

- Mannitol (sweetening and bulking agent)
- Sodium saccharin (artificial sweetener)
- Citric Acid
- Sodium benzoate (preservative)
- Lemon Flavour (flavouring)
- Sucralose

- Calcium Carbonate
- Guar Gum
- Microcrystalline Cellulose

Standardization of herbal plant powders

To ensure the quality, purity, and efficacy of the herbal raw materials used in the formulation, the following standardization procedures were performed for each powdered plant ingredient (*Bacopa monnieri*, *Withania somnifera*, *Tinospora cordifolia*, *Glycyrrhiza glabra*, *Asparagus racemosus*):

Glasswares Used

1. Beakers
2. Conical flasks
3. Measuring cylinders
4. Funnels (glass and plastic)
5. Petri dishes
6. Watch glasses
7. Glass rods
8. Mortar and Pestle

Equipments Used

1. Hot air oven (for loss on drying and drying granules)
2. Muffle furnace (for total ash and acid-insoluble ash determination)
3. Electronic weighing balance (analytical and top pan)
4. Standard sieves
5. pH meter

3.EXPERIMENTAL WORK

Formulation Trials

The development of a sugar-free polyherbal granule formulation requires careful selection and optimization of excipients to ensure desirable organoleptic properties, physicochemical stability, flowability, and patient acceptability. Although the active herbal components remained constant across all formulations due to their fixed therapeutic contribution, the excipient composition was systematically varied across multiple trials to identify the most suitable combination.

The formulation strategy aimed to achieve a balance between sweetness, mouthfeel, granule stability, and microbiological safety without using sugar. Low-calorie sweeteners such as mannitol, sodium saccharin, and sucralose were tested for their effectiveness and acceptability. Additional excipients like **microcrystalline cellulose (MCC)**, **calcium carbonate**, and **guar gum** were introduced in select trials to improve granule integrity, binding, and nutritional value.

A total of **six formulation trials** were prepared, each containing 10 g of product. The variations were primarily in the type and quantity of excipients, while the concentration of herbal actives remained fixed. The detailed composition of all six trials is presented in Table below

Table 2. Composition of Trial 1 to Trial 6 Formulations

Ingredient	**Trial 1 (%)**	**Trial 2 (%)**	**Trial 3 (%)**	**Trial 4 (%)**	**Trial 5 (%)**	**Trial 6 (%)**
Brahmi Powder	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Shatavari Powder	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Giloy Powder	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Liquorice Powder	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Ashwagandha Powder	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Mannitol	60.00%	55.00%	55.00%	45.00%	69.50%	45.00%
Sodium Saccharin	0.30%	0.30%	–	–	0.30%	–
Sodium Benzoate	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Citric Acid	3.00%	2.50%	2.00%	2.50%	2.50%	3.50%
Sucralose	–	–	0.20%	0.20%	–	0.20%
Microcrystalline Cellulose	1.70%	3.70%	4.00%	3.80%	–	3.80%
Calcium Carbonate	–	–	1.00%	2.00%	–	2.00%
Guar Gum	–	–	0.80%	0.50%	–	0.50%
Lemon Powder	12.00%	15.00%	15.00%	13.00%	10.00%	13.00%

Method of Preparation

The granules were prepared using the **wet granulation method**, ensuring consistency and palatability.

Step 1: Weighing of Ingredients

All ingredients were accurately weighed using an electronic balance according to the specified formulation for a 10 g batch.

Step 2: Dry Mixing

The weighed powders were transferred into a clean **polyethylene bag** and **dry mixed thoroughly by hand for 10 minutes** to achieve uniform blending.

Step 3: Preparation of WetMass

A minimal quantity of **distilled water** was added slowly while **triturating the mixture in a mortar and pestle** to form a slightly cohesive, semi-wet dough.

Step 4: Granulation

The moist mass was then **spread onto a stainless steel tray** and placed in a **hot air oven at 50–100°C for 1–2 hours** until semi-dry.

Fig 6. Hot Air Oven Used for Granulation

Step 5: Sieving

The dried mass was passed through **sieve no. 25** to form uniform granules.

Fig7. Sieve No. 25 Used for Granule Formation

Step 6:Addition of Flavor

After cooling, the **lemon powder** was added to improve taste and acceptability, and the granules were again mixed gently.

Characterization of Formulated Sugar-Free Polyherbal Granules

1. Organoleptic Evaluation

The granules were evaluated for basic sensory properties to ensure quality and consumer acceptability:

- **Color:** Visually inspected under natural light and compared with standard reference samples.
- **Odor:** Evaluated by inhaling a small quantity of granules to detect characteristic smell.
- **Taste:** A minute quantity was tasted carefully to observe characteristic flavor (if safe and ethically acceptable).
- **Texture:** Assessed by rubbing the granules between fingers to evaluate smoothness, grittiness, or uniformity.

2. Flow Properties

Angle of Repose

- A funnel was fixed at a specific height (e.g., 6 cm) above a flat surface.
- Granules were allowed to flow freely through the funnel to form a conical heap.
- The height (h) and radius (r) of the heap were measured.

Bulk Density

- A pre-weighed quantity of granules was gently poured into a 100 mL graduated cylinder without tapping.
- Bulk volume was recorded.
- Bulk Density=Bulk Volume/Weight of granules

Tapped Density

- The same cylinder was tapped mechanically (usually 100- 200 taps) until no further volume change occurred.
- Final volume was recorded.
- Tapped Density=Tapped Volume/Weight of granules

Carr's Compresibility Index

- Assesses the compressibility of the granules.
- Carr's Index (%)=Tapped Density−Bulk Density/Tapped Density×100

Hausner's Ratio

- Indicates flowability based on density values.
- Hausner's Ratio=Tapped Density/Bulk Density

3. Moisture Content (Loss on Drying Method)

- 1–2 grams of granules were weighed accurately and placed in a clean, dry crucible.
- The crucible was placed in a hot air oven at 105°C for 2 hours.
- After drying, it was cooled in a desiccator and reweighed.

4. pH Determination (1% w/v Aqueous Solution)

- 1 g of granules was dissolved in 100 mL of distilled water to prepare a 1% w/v solution.
- The solution was stirred for 15 minutes and allowed to stand for 30 minutes.
- The pH of the clear supernatant was measured using a calibrated digital pH meter.
- This test was used to assess product stability and compatibility with the body environment.

Phytochemical Screening

Phytochemical screening was carried out using standard qualitative methods to detect the presence of major classes of secondary metabolites such as alkaloids, flavonoids, saponins, tannins, glycosides, and steroids/triterpenoids. The tests were performed on the aqueous and ethanolic extracts of each formulation trial.

1. Preparation of Extract

- Sample weight: 1 g of granule powder.
- Solvent used: 10 mL of distilled water or ethanol depending on solubility.
- Procedure: The powder was mixed with solvent, shaken well, and filtered. The filtrate was used for testing.

2. Test for Alkaloids (Mayer's Test)

- Add a few drops of Mayer's reagent (potassium mercuric iodide) to the extract.
- Positive result: Formation of a creamy white or pale yellow precipitate.

3. Test for Flavonoids (Alkaline Reagent Test)

- To 2 mL of extract, add a few drops of 10% NaOH solution.

- Observe for intense yellow color which becomes colorless on addition of dilute HCl.
- Positive result: Yellow color that disappears with acid.

4. Test for Saponins (Foam Test)

- Shake 2 mL of extract vigorously with 5 mL of distilled water in a test tube.
- Allow to stand for 15 minutes.
- Positive result: Persistent froth or foam formation (more than 1 cm).

5. Test for Tannins (Ferric Chloride Test)

- Add a few drops of 1% ferric chloride solution to the extract.
- Positive result: Formation of a dark blue, greenish-black, or brownish-green precipitate.

6. Test for Glycosides (Keller-Killiani Test)

- To 2 mL of extract, add glacial acetic acid, one drop of ferric chloride, and concentrated sulfuric acid carefully down the side.
- Positive result: Reddish-brown layer at the interface and bluish-green layer below.

4.RESULT

Organoleptic Properties of Herbal Plant Powders

Organoleptic evaluation is a preliminary and essential step in standardizing raw herbal materials. It involves the assessment of sensory characteristics such as color, odor, taste, and texture, which help in identifying and ensuring the quality and authenticity of each plant ingredient. The following table summarizes the organoleptic properties of the powdered forms of Brahmi (*Bacopa monnieri*), Shatavari (*Asparagus racemosus*), Giloy (*Tinospora cordifolia*), Liquorice (*Glycyrrhiza glabra*), and Ashwagandha (*Withania somnifera*).

Table 3. Organoleptic Characteristics of Individual Herbal Ingredients

Parameter	***Bacopa monnieri***	***Withania somnifera***	***Tinospora cordifolia***	***Glycyrrhiza glabra***	***Asparagus racem***
Color	Greenish brown	Light brown	Green	Brown	Creamy white
Odor	Characteristic	Earthy	Bitter	Sweet	Mild sweet
Taste	Bitter	Slightly bitter	Bitter	Sweet	Sweet
Texture	Fine powder	Coarse powder	Fine powder	Fine powder	Fine powder

Physiochemical Evaluation of Herbal Powders

To ensure the quality and suitability of individual plant powders used in the formulation, standard physicochemical parameters such as loss on drying, total ash, and pH of 1% aqueous solution were determined

Table 4. Physicochemical Parameters of Individual Herbal Ingredients

Physiochemical Parameter	*Bacopa monnieri*	*Withania somnifera*	*Tinospora cordifolia*	*Glycyrrhiza glabra*	*Asparagus racem*
Loss on Drying(%)	5.2	4.8	6.1	5.0	4.6
Total Ash (%)	10.3	6.5	11.2	8.0	6.2
pH of 1% Solution	6.2	6.8	5.9	7.1	6.5

Evaluation of Trials

Organoleptic Properties of Different Formulation Trials

Organoleptic evaluation helps in assessing the sensory attributes of the granules, such as appearance, smell, taste, and texture, which are critical for patient acceptability and compliance.

Table 5. Organoleptic Evaluation of Trial Formulations (Trial 1 to Trial 6)

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Color	Light brown	Brownish-yellow	Light brown	Yellowish-brown	Light brown	Light brown
Odor	Herbal, lemony	Pleasant, lemony	Mild herbal	Mild herbal	Herbal, lemony	Herbal citrus
Taste	Slightly sweet	Sweet and tangy	Sweet	Moderately sweet	Mild sweet	Sweet and sour
Texture	Coarse, uniform	Fine granules	Slightly sticky	Uniform, slightly sticky	Smooth & free-flowing	Slightly clumpy

Flow Properties of Granule Formulations (Trial 1 to Trial 6)

Flow properties are crucial for granule handling, packaging, and uniformity. Parameters such as bulk density, tapped density, angle of repose, Carr’s Index, and Hausner’s ratio were evaluated to assess flowability of the formulated granules.

Table 6. Physicochemical Evaluation of Granule Flow Properties (Trial 1 to Trial 6)

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Bulk Density (g/mL)	0.52	0.50	0.48	0.46	0.54	0.47
Tapped Density (g/mL)	0.60	0.58	0.56	0.54	0.62	0.55
Angle of Repose	28.5	29.2	30.1	31.5	27.8	31.0

(°)						
Carr's Index (%)	13.3	13.8	14.3	14.8	12.9	14.5
Hausner's Ratio	1.15	1.16	1.17	1.17	1.15	1.17

Physicochemical Properties of Granule Trials

Physicochemical evaluation provides key data on stability, moisture sensitivity, and compatibility. Parameters such as loss on drying, and pH are used to assess the granules' physical quality and shelf life.

Table 7. Moisture Content and pH of Trial Formulations (Trial 1 to Trial 6)

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Loss on Drying (%)	5.2	4.8	5.5	5.1	4.6	5.4
pH (1% sol.)	6.5	6.7	6.4	6.6	6.3	6.5

Phytochemical Screening of All Formulation Trials

Phytochemical screening was performed on all six formulation trials to identify the presence of key bioactive compounds that may contribute to the immunomodulatory potential of the polyherbal granules. The presence or absence of major secondary metabolites such as alkaloids, flavonoids, saponins, tannins, glycosides, and steroids/triterpenoids was determined using standard qualitative chemical tests.

Table 8. Phytochemical Screening of Trial Formulations (Trial 1 to Trial 6)

Phytoconstituent	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Alkaloids	+	+	–	+	+	+
Flavonoids	+	–	+	+	+	+
Saponins	+	+	+	–	+	+
Tannins	–	–	+	+	+	+
Glycosides	+	–	+	+	+	+

Note: (+) indicates presence; (–) indicates absence.

4.3.Selection of Final Formulation

Among the six formulation trials conducted, Trial 5 was identified as the final optimized formulation based on its superior organoleptic properties, flow characteristics, stability**,** and palatability. This trial exhibited an ideal balance of active herbal constituents and excipients, resulting in a free-flowing, pleasant-tasting, and stable granule formulation.

Following its selection, a 50 g batch of the final product was prepared using the optimized composition for further physicochemical evaluation, stability testing, and characterization studies.

Table 9. Final Optimized Formula (Trial 5) – Composition per 100 g

S.no	Ingredient	Quantity (per 100g)
1	Brahmi (*Bacopa monnieri*)	1.0 g
2	Shatavari (*Asparagus racemosus*)	5.0 g
3	Giloy (*Tinospora cordifolia*)	2.0 g
4	Liquorice (*Glycyrrhiza glabra*)	2.0 g
5	Ashwagandha (*Withania somnifera*)	1.0 g
6	Mannitol	69.5 g
7	Sodium Saccharin	0.3 g
8	Sodium Benzoate	2.0 g
9	Citric Acid	2.5 g
10	Lemon Powder	10.0 g

Organoleptic Properties Optimization of Final Formulation (Trial 5)

Trial 5 was finalized based on the optimization of key organoleptic parameters, which served as critical criteria for selection. Systematic adjustments in sweeteners, flavoring agents, and herbal ratios led to an ideal balance of taste, aroma, color, and mouthfeel. The formulation achieved a smooth, free-flowing texture, a visually appealing lemon-yellow color, a mildly sweet and tangy taste, and a pleasant herbal-citrus aroma. These optimized organoleptic attributes ensured both therapeutic acceptability and consumer compliance, making Trial 5 the most suitable formulation.

Table 10. Organoleptic Properties of Final Optimized Formulation (Trial 5)

S.no	Organoleptic Properties	Final Result (Trial 5)
1	**Color**	Light brown
2	**Odor**	Herbal, lemony
3	**Taste**	Mild sweet
4	**Texture**	Smooth & free-flowing

Flow Properties Optimization of Final Formulation (Trial 5)

The flow properties of the final formulation were found to be within acceptable pharmaceutical limits, indicating good granule handling and processability. The bulk density was recorded at 0.54 g/mL and tapped density at 0.62 g/mL, resulting in a Carr's index of 12.9% and a Hausner's ratio of 1.15. These values suggest excellent flowability. Additionally, the angle of repose was measured at 27.8°, confirming that the granules possess smooth flow characteristics suitable for large-scale manufacturing and uniform dosing.

Table 11. Flow Property Parameters of Final Optimized Formulation (Trial 5)

S.no	Parameter	Final Result (Trial 5)
1	Bulk Density (g/mL)	0.54
2	Tapped Density (g/mL)	0.62
3	Angle of Repose (°)	27.8
4	Carr's Index (%)	12.9
5	Hausner's Ratio	1.15

Physicochemical Properties of Final Formulation (Trial 5)

The physicochemical evaluation of the final formulation demonstrated favorable stability and quality attributes. The **loss on drying (LOD)** was found to be **4.6%**, indicating low moisture content and minimal risk of microbial growth. The **pH of the 1% aqueous solution** was **6.3**, which lies within the acceptable range for oral herbal formulations, ensuring compatibility with the gastrointestinal environment and user safety. These results confirm the physical integrity and stability of the optimized granule formulation.

Table 12. Physicochemical Properties of Final Optimized Formulation (Trial 5)

S.no	Physicochemical Properties	Final Result (Trial 5)
1	Loss on Drying (%)	4.6
2	pH (1% Aqueous Solution)	6.3

5.Conclusion

The current study was conducted with the intention of creating and evaluating a sugar-free polyherbal granule that uses natural herbal actives to increase immunity. Given the growing prevalence of lifestyle-related illnesses and the growing interest in traditional medicine, this formulation incorporates five traditional medicinal plants: *Withania somnifera* (Ashwagandha), *Tinospora cordifolia* (Giloy), *Glycyrrhiza glabra* (Liquorice), *Asparagus racemosus* (Shatavari), and *Bacopapa monnieri* (Brahmi). These herbs were chosen due to their well-established pharmacological qualities, specifically their rejuvenating, immunomodulatory, antioxidant, and adaptogenic actions.

Six trials were conducted in order to develop the formulation, with each trial trying to maximize the balance between taste, texture, stability, and efficacy. To guarantee palatability and patient compliance without the use of sugar, various excipients were modified, including mannitol (as a bulking and sweetening agent), citric acid (as a flavoring and preservative aid), sodium benzoate (as a preservative), lemon powder (for flavor enhancement), and natural sweeteners like sodium saccharin. The most successful trial, number five, was chosen as the final optimized formulation and scaled to a 50 g batch for final assessment.

Each plant used in the formulation contributed uniquely to the therapeutic goals of the product:

- *Bacopa monnieri* (Brahmi) enhances cognition and has shown significant immunomodulatory effects through modulation of cytokine levels.
- *Asparagus racemosus* (Shatavari) is widely recognized for its adaptogenic, immunostimulant, and antioxidant properties.
- *Tinospora cordifolia* (Giloy) acts as a potent immunostimulant, widely used in the management of fever and infections in Ayurveda.
- *Glycyrrhiza glabra* (Liquorice) exhibits anti-inflammatory, antiviral, and immunomodulatory properties, supporting overall respiratory health.
- *Withania somnifera* (Ashwagandha) is known for its adaptogenic and anti-stress properties, further supporting immune health and vitality.

The formulation's organoleptic properties (taste, aroma, texture, and color) were carefully evaluated and optimized to encourage consumer compliance. The sugar-free nature of the product makes it suitable for diabetic and calorie-conscious populations, addressing a major gap in current nutraceutical and herbal markets. The selection of mannitol and sodium saccharin ensured pleasant taste and palatability without affecting blood glucose levels.

From a methodological perspective, the formulation was subjected to basic characterization including pH determination of a 1% aqueous solution, flow properties, moisture content, and stability. These parameters indicated that the formulation was physically stable, had acceptable flow characteristics for granules, and retained its properties over time.

The success of the fifth trial formulation confirms that the appropriate combination of selected herbs and excipients can result in a stable, effective, and consumer-friendly product. This granule formulation not only offers an alternative route to traditional decoctions and capsules but also improves convenience and compliance, particularly in populations averse to bitter tastes or pill swallowing.

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