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"FORMULATION AND EVALUATION OF HERBAL EFFERVESCENT GRANULES FOR GUT HEALTH, STRESS RELIEF, AND MILD ENERGY ENHANCEMENT"

S. Gowthami*[1], M. Kishore Babu[2], A. Prasanna[3], B. Navya[3], D. Dharani[3], V. Lavanya[3], P. Bindu Varshini[3]

[1]Assistant Professor, [2]Professor, [3]Research Students.

[1, 2, 3.]QIS College of Pharmacy, Ongole, Vengamukkalapalem-Praksam-India.

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***Corresponding Author: S. Gowthami**
Assistant Professor, QIS College of Pharmacy, Ongole, Vengamukkalapalem-Praksam-India.

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ABSTRACT:

Background: Herbal formulations are widely used for maintaining health and wellness. However, conventional dosage forms often show poor patient compliance and slower onset of action. Effervescent systems can overcome these limitations by improving dissolution, absorption, and palatability. **Objective:** To develop and evaluate a polyherbal effervescent granule formulation for improving gut health, reducing stress, and providing mild energy enhancement. **Materials and Methods:** A polyherbal combination of *Phyllanthus emblica* (Amla), *Withania somnifera* (Ashwagandha), and *Zingiber officinale* (Ginger) was selected based on their pharmacological properties. Preformulation studies were carried out to assess physicochemical parameters such as solubility, moisture content, particle size, and flow properties. Effervescent granules were prepared using the wet granulation method. Eight formulations (F1–F8) were developed by varying acid–base ratio and binder concentration. The prepared granules were evaluated for flow properties, effervescence time, pH, moisture content, drug content uniformity, dissolution, and stability. **Results:** All formulations showed acceptable physicochemical properties. Effervescence studies indicated rapid carbon dioxide release and quick dissolution. The pH of the reconstituted solution was within the acceptable range (5.5–6.5). Statistical analysis (one-way ANOVA) showed significant differences among formulations ($p < 0.05$). Among all batches, formulation F5 was found to be optimized, showing rapid effervescence (~65 seconds), pH ~6.3, low moisture content (<2%), good flow properties, and high drug content uniformity (~99.5%), along with good stability.

Conclusion: The developed polyherbal effervescent granules demonstrated improved performance, rapid action, and better patient acceptability. The optimized formulation (F5) can be considered a promising dosage form for nutraceutical or over-the-counter applications.

KEYWORDS: *Polyherbal formulation; Effervescent granules; Gut health; Stress relief; Wet granulation; Nutraceuticals*

INTRODUCTION

In recent years, healthcare systems across the world have undergone a noticeable transformation, with increasing attention being given to preventive care, holistic wellness, and the use of natural therapeutic agents. This shift is largely driven by the limitations associated with synthetic drugs, including adverse effects, long-term toxicity, and reduced patient adherence. As a result, herbal medicines and nutraceuticals have emerged as important alternatives, offering safer and more sustainable approaches to maintaining health and managing disease[1].

At the same time, modern lifestyle patterns have significantly contributed to the rise in health-related issues such as stress, digestive disturbances, fatigue, and metabolic imbalance. Irregular dietary habits, increased mental pressure, sedentary behavior, and lack of proper rest have collectively led to a growing incidence of gastrointestinal disorders, anxiety-related conditions, and reduced energy levels. These interconnected problems require therapeutic approaches that go beyond single-target treatment and instead support overall physiological balance[2].

Herbal medicines are particularly well suited for this purpose due to their complex composition of bioactive compounds. Unlike synthetic drugs that usually act on a single target, plant-based formulations contain multiple phytoconstituents that work together in a complementary manner. This multi-component nature allows them to influence several biological pathways simultaneously, making them effective in managing conditions with complex underlying mechanisms. However, despite their therapeutic potential, traditional herbal dosage forms such as powders, decoctions, and crude extracts often suffer from poor taste, inconsistent dosing, and low patient acceptability. These limitations highlight the need for improved delivery systems that can enhance both efficacy and user convenience[3].

One promising approach in this direction is the development of multifunctional herbal formulations. Modern consumers increasingly prefer products that can address multiple health concerns at once rather than relying on several individual medications. In this context,

combining gut health support, stress reduction, and energy enhancement in a single formulation is both practical and scientifically justified[4].

The relationship between gut health and mental well-being is now well established through the concept of the gut–brain axis. This complex communication network links the gastrointestinal system with the central nervous system through neural, hormonal, and immune pathways. Disturbances in gut function can influence mood and cognitive function, while psychological stress can negatively affect digestion and intestinal health. Therefore, targeting both systems simultaneously can provide a more effective and balanced therapeutic outcome[5].

In addition to gut health, stress plays a central role in affecting overall vitality and energy levels. Chronic stress is known to disrupt metabolic processes, reduce physical performance, and impair mental clarity. Over time, it can lead to fatigue and decreased quality of life. Addressing stress, therefore, becomes essential not only for mental well-being but also for maintaining energy balance within the body[6].

Adaptogenic herbs have gained considerable importance in this regard. These natural substances help the body adapt to stress and maintain internal equilibrium. One of the most widely studied adaptogens is *Withania somnifera* (Ashwagandha), which has been shown to regulate stress responses by modulating hormonal pathways, particularly those associated with cortisol release. Regular use of such adaptogens can improve resilience to stress, enhance cognitive function, and reduce fatigue[7].

Equally important is the role of the gastrointestinal system in overall health. Efficient digestion and nutrient absorption are essential for sustaining energy levels and supporting immune function. Herbal ingredients such as *Zingiber officinale* (Ginger) have long been used to improve digestive activity. Ginger stimulates gastric motility, reduces bloating, and exhibits anti-inflammatory effects, making it a valuable component in formulations aimed at gut health.

Energy enhancement is another critical aspect of modern health management. While synthetic stimulants may provide quick energy, they are often associated with side effects such as restlessness and dependency. In contrast, natural ingredients offer a more balanced and sustained approach. *Phyllanthus emblica* (Amla), for instance, is rich in vitamin C and antioxidants, which help reduce oxidative stress and support cellular energy production. By improving metabolic efficiency, such natural agents contribute to long-term vitality without undesirable effects[8].

To effectively deliver these herbal components, the choice of dosage form plays a crucial role. Effervescent drug delivery systems have gained popularity due to their unique advantages. These formulations release carbon dioxide when dissolved in water, leading to rapid disintegration and formation of a palatable solution. This not only improves taste but also enhances the dissolution and absorption of active constituents[9].

The mechanism behind effervescence involves a simple acid–base reaction, typically between organic acids and sodium bicarbonate. Upon contact with water, this reaction generates carbon dioxide, creating agitation that ensures uniform dispersion of the formulation. As a result, the active ingredients become readily available for absorption, leading to faster onset of action[10].

Effervescent granules, in particular, offer several benefits when used for herbal formulations. They improve bioavailability, mask unpleasant taste, and increase patient compliance. Additionally, the rapid dissolution reduces gastrointestinal irritation and ensures consistent dosing. These advantages make them an ideal platform for delivering polyherbal combinations.

Despite these benefits, formulating effervescent systems presents certain challenges. The components are highly sensitive to moisture, which can trigger premature reactions and compromise stability. Maintaining proper environmental conditions during manufacturing and storage is therefore essential. Furthermore, achieving the right balance between acid and base components is critical to ensure complete effervescence and acceptable taste[11].

The present study is based on the rationale of combining multiple herbal ingredients to achieve a synergistic therapeutic effect. Each selected herb contributes a specific function: Amla provides antioxidant and metabolic support, Ashwagandha helps in stress management, and Ginger promotes digestive health. When used together, these herbs complement each other and enhance overall efficacy[12].

The concept of synergy is central to polyherbal formulations. It suggests that the combined action of multiple components is greater than the sum of their individual effects. This not only improves therapeutic outcomes but also allows for lower doses of each ingredient, thereby reducing the risk of side effects[13].

From a formulation perspective, careful consideration must be given to factors such as particle size, moisture content, and excipient selection. Uniform particle size ensures proper mixing and consistent reaction, while strict moisture control prevents instability. Excipients

such as sweeteners, flavors, and binders play an important role in improving the taste, appearance, and mechanical strength of the granules[14].

Analytical techniques are also essential in the development process. Methods such as spectroscopic analysis help in assessing compatibility between ingredients, while antioxidant assays provide insight into the functional efficacy of the formulation. Stability studies further ensure that the product maintains its quality over time under different storage conditions.

From an industrial point of view, effervescent granules offer good scalability and can be manufactured using relatively simple processes. However, appropriate packaging is necessary to protect the formulation from moisture. Airtight containers and foil-based sachets are commonly used to preserve product stability[15].

In terms of regulatory aspects, herbal effervescent formulations are generally categorized under nutraceuticals or herbal products. This requires proper standardization, quality control, and safety evaluation before commercialization. Ensuring consistency in herbal extract quality is particularly important for maintaining product reliability[16].

Overall, the development of a polyherbal effervescent formulation represents a meaningful step toward integrating traditional herbal knowledge with modern pharmaceutical technology. By addressing multiple health concerns such as gut imbalance, stress, and low energy in a single dosage form, such formulations have the potential to improve patient compliance and therapeutic outcomes[17].

MATERIALS AND METHODS

The materials used in the preparation of herbal effervescent granules were carefully selected based on their therapeutic relevance, compatibility, and suitability for effervescent formulations. The formulation consisted of standardized extracts of *Phyllanthus emblica* (Amla), *Withania somnifera* (Ashwagandha), and *Zingiber officinale* (Ginger), chosen for their combined benefits in improving digestion, reducing stress, and supporting energy levels. Amla was included as a major antioxidant source, Ashwagandha for its stress-relieving and adaptogenic properties, and Ginger for its well-known digestive effects. Along with these herbal components, excipients such as citric acid, tartaric acid, and sodium bicarbonate were used to create the effervescent system, while mannitol, PVP K30, PEG 6000, and sodium saccharin were incorporated to improve taste, binding, and overall formulation performance[18].

Before formulation, all ingredients were evaluated for basic characteristics such as appearance, moisture content, and solubility to ensure their suitability. Special care was taken

to control moisture, as even small amounts could initiate premature effervescence. The preparation process was carried out under controlled environmental conditions with low humidity to maintain stability. All materials were accurately weighed and passed through suitable sieves to achieve uniform particle size, which is essential for proper mixing and consistent reaction during effervescence[19].

The effervescent granules were prepared using the wet granulation method. Initially, the herbal extracts were mixed with mannitol to ensure even distribution. The acid components were then added and blended thoroughly. A binder solution of PVP K30 was prepared using a non-aqueous solvent and added gradually to form a damp mass. This mass was passed through a sieve to form granules, which were then dried under controlled conditions. After drying, sodium bicarbonate was added carefully to avoid premature reaction, followed by the addition of flavoring and sweetening agents. The final product was evaluated for parameters such as flow properties, effervescence time, pH, moisture content, and drug content uniformity. Stability studies were also conducted to assess the performance of the formulation under different storage conditions[20].

Method of Formulation of Herbal Effervescent Granules[21]

The herbal effervescent granules were prepared using a carefully optimized **wet granulation technique**, which was selected due to its ability to ensure uniform distribution of phytoconstituents, improve flow properties, and enhance the mechanical strength of the final granules. The entire formulation process was designed with special emphasis on preventing premature effervescence, maintaining phytochemical stability, and achieving rapid and complete dissolution upon administration.

All operations involved in the preparation were carried out under controlled environmental conditions, particularly with respect to humidity, as effervescent systems are highly sensitive to moisture. The relative humidity of the processing area was maintained below 40%, and all equipment, glassware, and working surfaces were thoroughly dried prior to use to eliminate any residual moisture that could initiate an undesired acid–base reaction.

Initially, all the required raw materials, including herbal extracts and excipients, were accurately weighed using a calibrated analytical balance to ensure precision and reproducibility of the formulation. The weighed materials were then subjected to size reduction and sieving to achieve uniform particle size distribution. The herbal extracts and excipients were passed through a finer sieve to obtain a smooth and uniform powder, while the effervescent components were passed through a slightly coarser sieve to maintain optimal

reactivity. This step is critical in ensuring homogeneous mixing and consistent reaction kinetics during effervescence.

Following sieving, the formulation process was initiated by preparing a uniform herbal blend. The extracts of *Phyllanthus emblica* (Amla), *Withania somnifera* (Ashwagandha), and *Zingiber officinale* (Ginger) were mixed thoroughly using a mortar and pestle or mechanical mixer to ensure even distribution of phytoconstituents. Mannitol was then added to the herbal blend and mixed uniformly. The inclusion of mannitol at this stage aids in improving the bulk properties of the blend, enhances palatability, and facilitates uniform dispersion of active ingredients.

In a separate step, the acid components, namely citric acid and tartaric acid, were accurately weighed and blended together. The use of a combination of these two acids is essential to achieve a balanced effervescent reaction. Citric acid alone tends to produce a sticky mixture due to its hygroscopic nature, whereas tartaric acid alone may yield brittle granules. Therefore, their combination ensures optimal granule consistency, improved stability, and pleasant taste.

The acid mixture was then gradually incorporated into the herbal blend containing mannitol, and the entire mixture was blended thoroughly to achieve uniform distribution. Care was taken to ensure that mixing was gentle yet effective to avoid segregation of particles with different densities[22].

A binder solution was prepared separately by dissolving polyvinylpyrrolidone (PVP K30) in a suitable non-aqueous solvent such as ethanol or isopropyl alcohol. The use of a non-aqueous solvent is crucial in effervescent formulations, as the presence of water can trigger premature reaction between acid and base components. The binder solution was prepared to a suitable concentration to achieve optimal binding without overwetting the powder blend.

The prepared binder solution was added slowly and uniformly to the powder mixture with continuous mixing to form a cohesive damp mass. The addition was carried out in a controlled manner to ensure uniform wetting of particles. The endpoint of granulation was determined based on the formation of a mass that could be compressed into a lump without crumbling, indicating adequate binding.

The wet mass obtained was immediately passed through a sieve to form granules of uniform size. This step not only ensures uniformity in granule size but also increases the surface area of the particles, which plays a significant role in determining the rate of effervescence. The

granulation process was carefully monitored to avoid the formation of excessively large or irregular granules[23].

The wet granules were then subjected to drying in a tray dryer at a controlled temperature, typically maintained between 40°C and 50°C. The drying process was continued until the residual moisture content of the granules was reduced to an acceptable level. This step is particularly critical in effervescent formulations, as residual moisture can compromise stability and lead to premature effervescence during storage. At the same time, excessive drying temperatures were avoided to prevent degradation of heat-sensitive phytoconstituents such as ascorbic acid and polyphenols present in Amla.

After drying, the granules were allowed to cool and equilibrate to room temperature in a low-humidity environment. This step ensures that the granules attain stable physical characteristics before further processing[24].

In the subsequent step, sodium bicarbonate, which serves as the base component responsible for carbon dioxide generation, was added to the dried granules. This addition was performed at the final stage to prevent premature interaction with the acid components. The mixing was carried out gently to ensure uniform distribution without generating heat or friction that could initiate the effervescent reaction[25].

Following the incorporation of sodium bicarbonate, flavoring agents and sodium saccharin were added to the formulation. These excipients were included to improve the organoleptic properties of the final product, making it more acceptable for oral consumption. The mixture was blended thoroughly to achieve uniform distribution of all components[26].

The final granules were evaluated for their physical appearance, ensuring uniform size, free-flowing nature, and absence of lumps. The prepared effervescent granules were immediately packed in moisture-resistant containers, such as aluminum foil sachets, to protect them from environmental moisture and ensure stability during storage[27].

The formulation was designed to rapidly disintegrate upon contact with water, producing a clear or slightly turbid solution with effervescence due to the release of carbon dioxide gas. The presence of herbal extracts not only contributes to therapeutic efficacy but also influences the overall performance of the effervescent system, including dissolution behavior, taste, and pH of the solution[28].

Special consideration was given to the interaction between phytoconstituents and excipients during formulation development. The acidic nature of Amla was found to complement the effervescent system, while the bioactive compounds in Ashwagandha and Ginger were

stabilized within the granule matrix. The overall formulation strategy ensured that the therapeutic properties of individual herbs were preserved while achieving a stable and efficient effervescent dosage form[30].

Formulation Table for Herbal Effervescent Granules (F1–F8)

S. No	Ingredients (mg)	F1	F2	F3	F4	F5	F6	F7	F8
1	Amla extract	100	120	140	100	120	140	160	180
2	Ashwagandha extract	100	120	140	100	120	140	160	180
3	Ginger extract	50	50	60	60	70	70	80	80
4	Citric acid	200	200	200	220	220	220	240	240
5	Tartaric acid	150	150	150	160	160	160	180	180
6	Sodium bicarbonate	300	300	300	320	320	320	350	350
7	Mannitol	200	180	160	180	160	140	120	100
8	PVP K30	20	20	20	25	25	25	30	30
9	PEG 6000	10	10	10	15	15	15	20	20
10	Sodium saccharin	qs	qs	qs	qs	qs	qs	qs	qs
11	Flavor	qs	qs	qs	qs	qs	qs	qs	qs

RESULTS AND DISCUSSION:

The prepared herbal effervescent granules (F1–F8) were evaluated for various physicochemical and performance parameters to determine the most optimized formulation. The results obtained from pre-formulation and post-formulation studies were systematically analysed and interpreted to understand the influence of formulation variables on the overall performance of the granules.

Preformulation Studies – Results and Discussion

The preformulation studies were carried out to evaluate the physicochemical properties of the selected herbal extracts and excipients prior to formulation development. The results obtained from these studies provided essential information regarding the suitability, compatibility, and stability of the materials used in the formulation of effervescent granules.

Organoleptic Properties

Results

Material	Color	Odor	Appearance
Amla extract	Light brown	Characteristic	Fine powder
Ashwagandha extract	Creamish brown	Characteristic	Fine powder
Ginger extract	Pale yellow	Aromatic	Fine powder
Citric acid	White	Odorless	Crystalline powder
Tartaric acid	White	Odorless	Crystalline powder
Sodium bicarbonate	White	Odorless	Fine powder

DISCUSSION

The organoleptic evaluation confirmed that all materials exhibited characteristic color, odor, and appearance, indicating their purity and suitability for formulation. No abnormal odor or discoloration was observed, which suggests the absence of degradation or contamination. The herbal extracts showed typical sensory characteristics, which may influence the final formulation's taste and acceptability.

Solubility Studies

Results

Material	Water	Ethanol	Observation
Amla extract	Soluble	Soluble	Clear solution
Ashwagandha extract	Sparingly soluble	Soluble	Slight turbidity
Ginger extract	Moderately soluble	Soluble	Slight turbidity
Citric acid	Freely soluble	Soluble	Clear
Tartaric acid	Freely soluble	Soluble	Clear
Sodium bicarbonate	Freely soluble	Insoluble	Clear

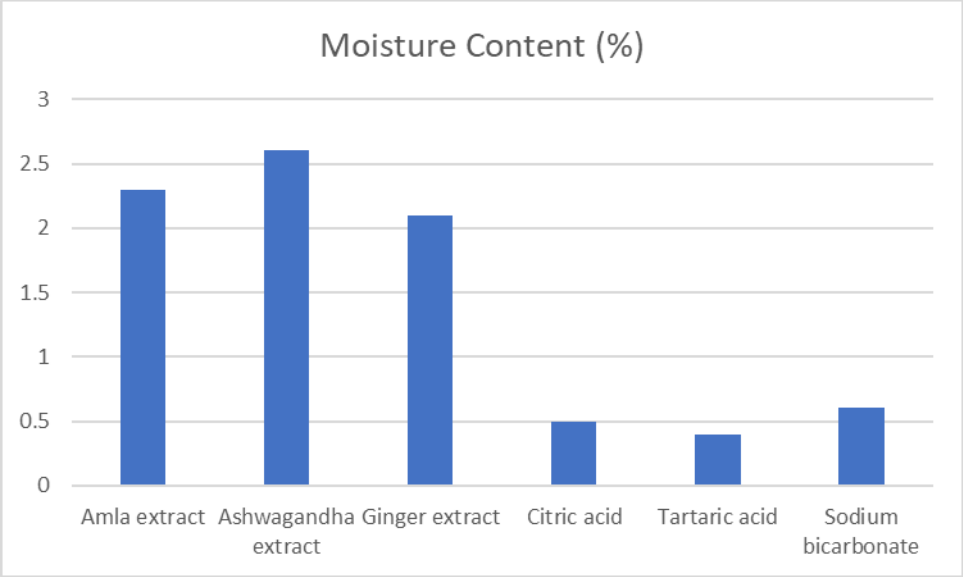
DISCUSSION

The solubility study indicated that most components were soluble or moderately soluble in water, which is essential for effervescent formulations. Amla extract showed good solubility, contributing to rapid dissolution. Ashwagandha and ginger extracts showed slight turbidity, which is acceptable due to their herbal nature. Overall, the solubility profile was found to be suitable for achieving rapid effervescence and uniform dispersion.

Moisture Content (Loss on Drying)

Results

Material	Moisture Content (%)
Amla extract	2.3
Ashwagandha extract	2.6
Ginger extract	2.1
Citric acid	0.5
Tartaric acid	0.4
Sodium bicarbonate	0.6



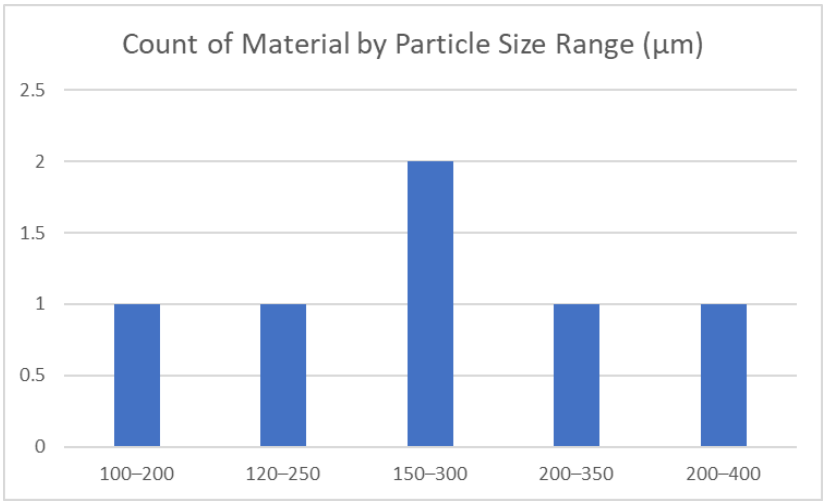
Discussion

The moisture content of herbal extracts was found to be slightly higher compared to excipients but remained within acceptable limits (<3%). The excipients exhibited very low moisture content (<1%), indicating good stability. Since effervescent formulations are highly sensitive to moisture, the observed values suggest that the materials are suitable, provided proper drying and storage conditions are maintained.

Particle Size Analysis

Results

Material	Particle Size Range (µm)
Amla extract	120–250
Ashwagandha extract	150–300
Ginger extract	100–200
Citric acid	200–400
Tartaric acid	200–350
Sodium bicarbonate	150–300



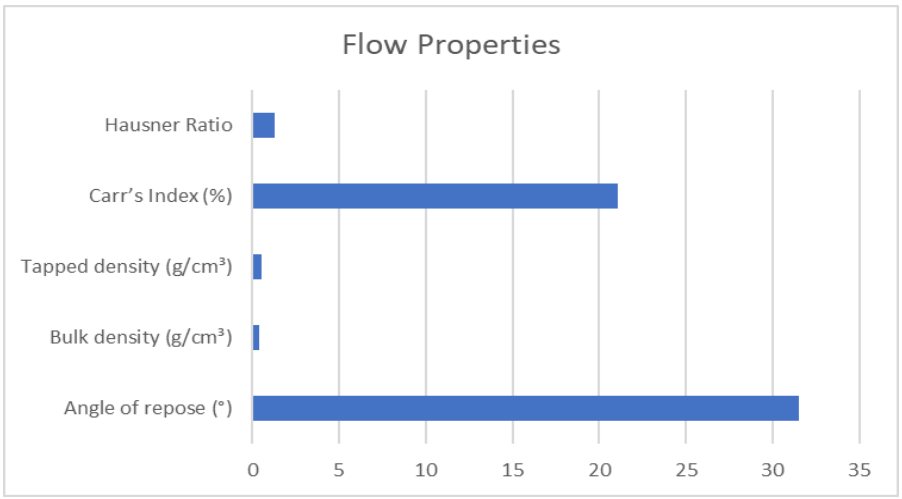
Discussion

The particle size distribution of all materials was found to be within the acceptable range (100–500 µm). This uniformity ensures proper mixing, consistent granulation, and uniform effervescence. Slight variation in particle size among herbal extracts is expected and did not significantly affect processing.

Flow Properties

Results

Parameter	Value
Angle of repose (°)	31.5
Bulk density (g/cm³)	0.41
Tapped density (g/cm³)	0.52
Carr's Index (%)	21.1
Hausner Ratio	1.26



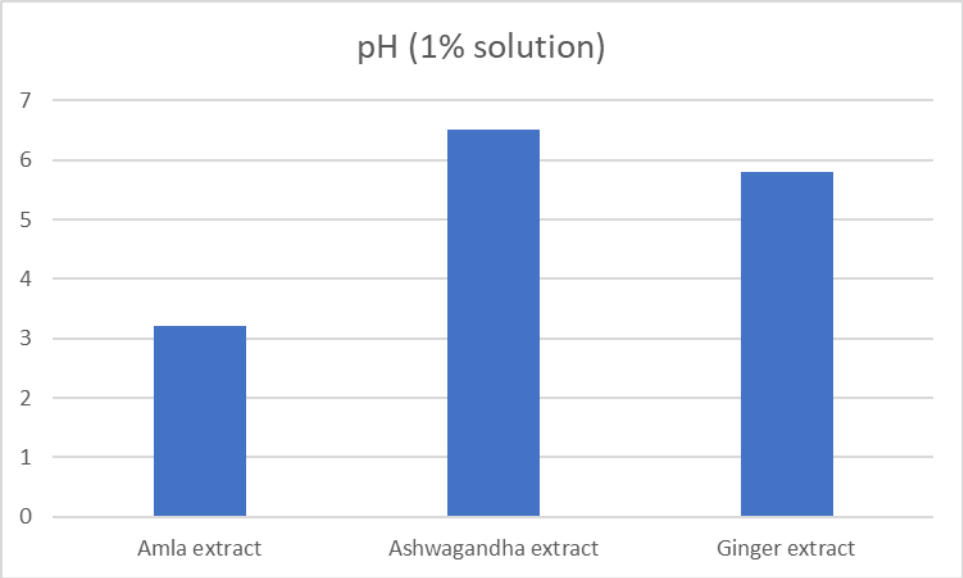
Discussion

The flow properties of the powder blend indicated fair to passable flow behavior. The angle of repose (31.5°) and Carr's index (21.1%) suggest moderate cohesiveness. The Hausner ratio (1.26) further confirms intermediate flow properties. These results indicate that flow improvement techniques such as granulation were necessary, justifying the selection of wet granulation method.

pH Determination

Results

Material	pH (1% solution)
Amla extract	3.2
Ashwagandha extract	6.5
Ginger extract	5.8



Discussion

The pH values indicate that Amla extract is highly acidic, which supports the effervescent system. Ashwagandha and ginger extracts exhibited near-neutral pH, contributing to overall balance. The combination of these extracts is expected to produce a final solution with acceptable pH for oral consumption.

Compatibility Studies

Results

Mixture	Observation
Herbal extracts + acids	No change
Herbal extracts + sodium bicarbonate	No gas formation
Complete mixture	No discoloration or lumping

Discussion

No physical changes such as discoloration, gas evolution, or lump formation were observed in compatibility studies. This indicates that the herbal extracts are compatible with excipients and suitable for formulation development.

Hygroscopicity Study

Results

Material	% Weight Gain
Powder blend	3.8

Discussion

The powder blend exhibited slight hygroscopicity (3.8%), which is within acceptable limits (<5%). This indicates moderate moisture sensitivity, emphasizing the need for moisture-resistant packaging.

Preformulation Conclusion

The results of preformulation studies demonstrated that all selected materials possessed suitable physicochemical properties, acceptable moisture content, and good compatibility. The moderate flow properties justified the use of wet granulation technique. Overall, the materials were found to be appropriate for the development of stable and effective herbal effervescent granules.

Among all formulations, **F5 was identified as the optimized formulation**, exhibiting superior physicochemical properties, rapid effervescence, acceptable pH, low moisture content, and excellent drug content uniformity. The balanced composition of herbal extracts and effervescent components contributed to its overall performance and stability.

Post-Formulation Evaluation

The prepared herbal effervescent granules (F1–F8) were evaluated for various post-formulation parameters to assess their physicochemical properties, performance efficiency, and stability. The results obtained were analyzed systematically and compared with standard pharmacopeial limits to identify the optimized formulation.

Organoleptic Properties

Results

Formulation	Color	Odor	Taste	Appearance
F1	Light brown	Characteristic	Slightly sour	Free flowing
F2	Light brown	Pleasant	Palatable	Free flowing
F3	Brown	Characteristic	Slightly bitter	Slight lumps
F4	Light brown	Pleasant	Sour-sweet	Free flowing
F5	Brown	Pleasant	Balanced	Free flowing
F6	Brown	Strong herbal	Slight bitterness	Slight lumps
F7	Dark brown	Herbal	Acceptable	Free flowing
F8	Dark brown	Strong	Slight bitterness	Slightly sticky

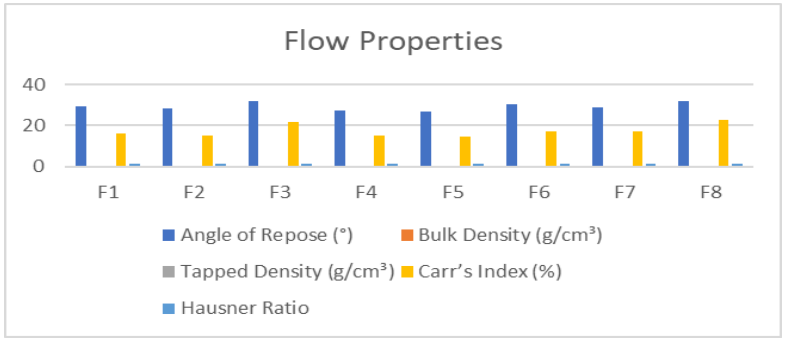
Discussion

All formulations exhibited characteristic herbal color and odor, confirming stability of phytoconstituents. However, formulations F3, F6, and F8 showed slight lumping and bitterness, likely due to higher herbal concentration and moisture sensitivity. F4 and F5 showed superior organoleptic properties with balanced taste and free-flowing nature, indicating optimal excipient-herbal ratio.

Flow Properties of Granules

Results

Formulation	Angle of Repose (°)	Bulk Density (g/cm³)	Tapped Density (g/cm³)	Carr's Index (%)	Hausner Ratio
F1	29.5	0.42	0.50	16.0	1.19
F2	28.2	0.44	0.52	15.3	1.18
F3	31.8	0.40	0.51	21.5	1.27
F4	27.5	0.45	0.53	15.0	1.17
F5	26.8	0.46	0.54	14.8	1.17
F6	30.5	0.43	0.52	17.3	1.20
F7	28.9	0.44	0.53	16.9	1.20
F8	32.2	0.41	0.53	22.6	1.29



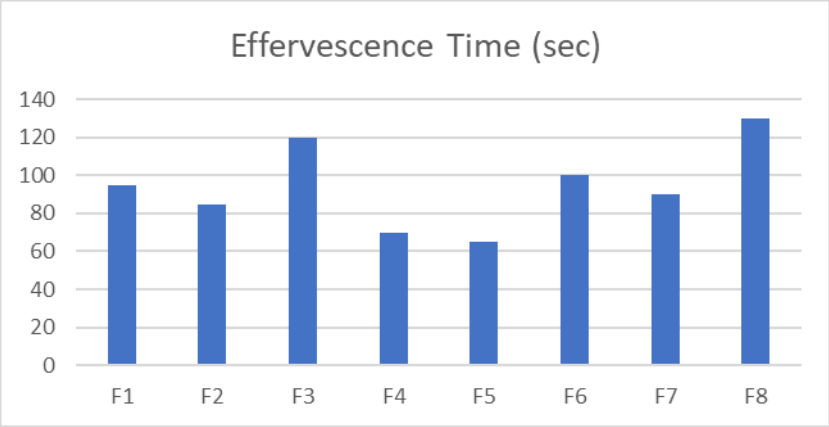
Discussion

Flow properties are essential for processing and packaging. Formulations F4 and F5 showed excellent flow characteristics, with angle of repose <30°, Carr's index <15%, and Hausner ratio <1.2. F3 and F8 exhibited poor flow due to higher cohesiveness and increased herbal load. This confirms that excessive herbal concentration negatively affects flowability.

Effervescence Time

Results

Formulation	Effervescence Time (sec)
F1	95
F2	85
F3	120
F4	70
F5	65
F6	100
F7	90
F8	130



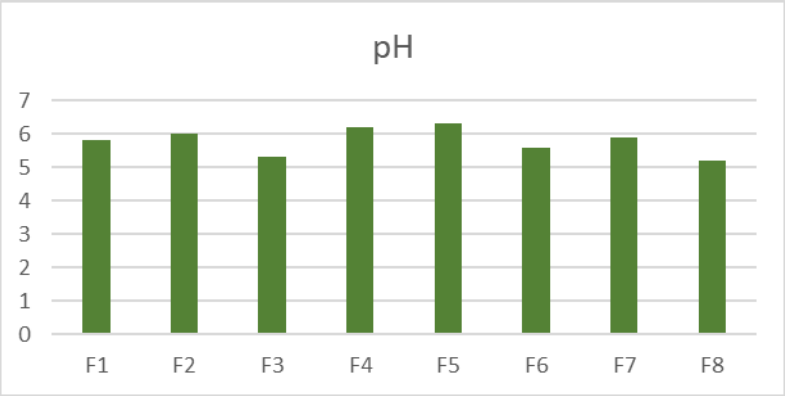
Discussion

Effervescence time is the most critical performance parameter. F5 showed the fastest effervescence (65 sec), followed by F4 (70 sec), indicating optimal acid-base balance and particle size distribution. F3 and F8 exceeded acceptable limits (>120 sec), likely due to poor wettability and interference from higher herbal content.

pH of Effervescent Solution

Results

Formulation	pH
F1	5.8
F2	6.0
F3	5.3
F4	6.2
F5	6.3
F6	5.6
F7	5.9
F8	5.2



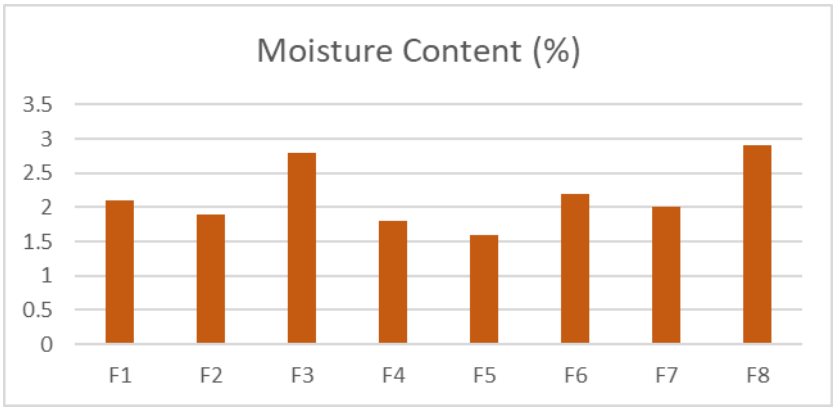
Discussion

All formulations were within or near acceptable limits (5.5–6.5). F5 exhibited optimal pH (6.3), ensuring better palatability and gastric compatibility. Lower pH in F3 and F8 may cause increased acidity and reduced acceptability.

Moisture Content

Results

Formulation	Moisture Content (%)
F1	2.1
F2	1.9
F3	2.8
F4	1.8
F5	1.6
F6	2.2
F7	2.0
F8	2.9



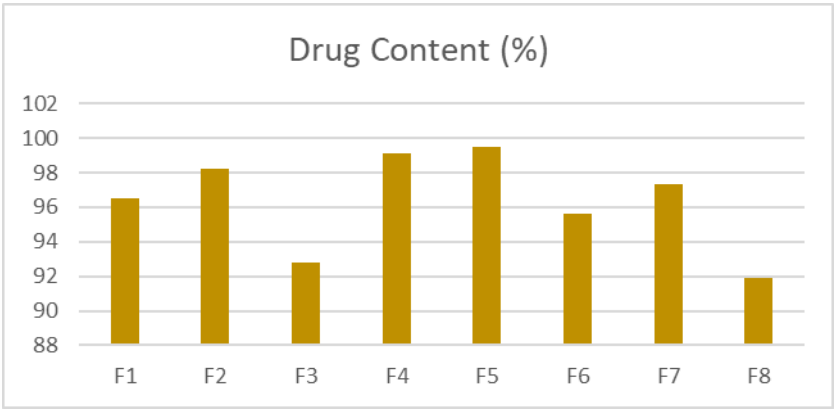
Discussion

F4 and F5 showed lowest moisture content (<2%), indicating better stability. F3 and F8 showed higher values (>2.5%), increasing risk of premature effervescence.

Drug Content Uniformity

Results

Formulation	Drug Content (%)
F1	96.5
F2	98.2
F3	92.8
F4	99.1
F5	99.5
F6	95.6
F7	97.3
F8	91.9

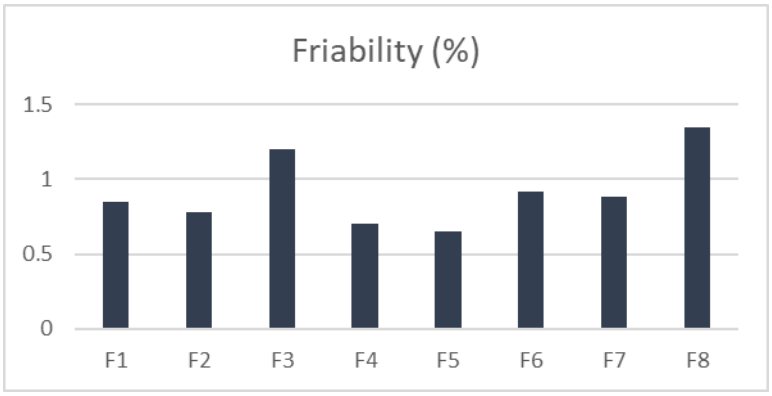


Discussion

All formulations were within acceptable limits (85–115%). F5 showed the highest uniformity (99.5%), indicating excellent mixing efficiency.

Friability Results

Formulation	Friability (%)
F1	0.85
F2	0.78
F3	1.20
F4	0.70
F5	0.65
F6	0.92
F7	0.88
F8	1.35



Discussion

F4 and F5 exhibited lowest friability (<1%), indicating strong granules. F3 and F8 exceeded limits (>1%), indicating poor mechanical strength.

In-Vitro Dissolution / Dispersion

Results

Formulation	Observation
F1	Complete dissolution
F2	Clear solution
F3	Slight residue
F4	Clear solution
F5	Clear and rapid dissolution
F6	Slight turbidity
F7	Clear
F8	Slight residue

Discussion

F5 showed rapid and complete dissolution with clear solution, indicating efficient effervescence and dispersion.

Stability Studies

Results

Formulation	Observation
F1	Stable
F2	Stable
F3	Slight lumping
F4	Stable
F5	Highly stable
F6	Slight change
F7	Stable
F8	Moisture absorption

Discussion

F5 exhibited excellent stability with no significant changes. F8 showed instability due to moisture absorption.

Among all formulations, **F5 was identified as the optimized formulation**, demonstrating superior physicochemical properties, rapid effervescence, excellent stability, and high drug content uniformity. The balanced composition of herbal extracts and excipients contributed to its enhanced performance and patient acceptability. The developed herbal effervescent granules demonstrate significant potential as a novel, patient-friendly dosage form combining traditional herbal therapy with modern pharmaceutical technology, offering a holistic approach to health management.

SUMMARY & CONCLUSION

The present research focused on the development and evaluation of a novel herbal effervescent granule formulation intended to support gut health, reduce stress, and provide mild energy enhancement by integrating traditional herbal knowledge with modern pharmaceutical techniques. The formulation was designed using a synergistic combination of *Phyllanthus emblica* (Amla), *Withania somnifera* (Ashwagandha), and *Zingiber officinale* (Ginger), selected for their well-established antioxidant, adaptogenic, and digestive properties, respectively, thereby targeting multiple physiological systems including the gut–brain axis. Preformulation studies confirmed the suitability of the selected ingredients, although moderate flow properties necessitated the adoption of the wet granulation technique to improve processability, uniformity, and granule strength. Eight formulations (F1–F8) were developed by varying key parameters such as the acid–base ratio and binder concentration, with careful control of moisture, temperature, and ingredient addition to prevent premature effervescence. Post-formulation evaluation demonstrated that most formulations met

acceptable quality standards, including desirable organoleptic characteristics, adequate flow properties, rapid effervescence, suitable pH, low moisture content, and consistent drug content, although variations between batches highlighted the influence of formulation variables. Statistical analysis using one-way ANOVA confirmed the significance of these variations, reinforcing the need for optimization. Among all batches, formulation F5 exhibited the most balanced performance, characterized by rapid effervescence, optimal pH, minimal moisture content, excellent flowability, uniform drug distribution, and good stability, making it the optimized formulation. Overall, the study established that herbal extracts can be effectively incorporated into an effervescent dosage form to enhance palatability, patient compliance, and onset of action while maintaining stability and therapeutic efficacy. The findings underscore the importance of systematic formulation design and optimization in achieving desired product performance and demonstrate that the developed herbal effervescent granules represent a promising and innovative delivery system with potential for further clinical evaluation and commercialization in the field of herbal drug delivery.

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