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Research Article

Formulation And Evaluation Of Polyherbal Nutraceutical Gummies

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ABSTRACT

Polyherbal nutraceutical gummies are an emerging chewable dosage form that combines the therapeutic potential of medicinal plants with the nutritional benefits of functional foods. The present study aimed to formulate and evaluate polyherbal nutraceutical gummies containing extracts of Nelumbo nucifera (Lotus Seed), Moringa oleifera (Moringa Leaves), Beta vulgaris (Beetroot), Carica papaya (Papaya Leaf), and Citrus limon (Lemon). These herbal ingredients were selected for their well-documented antioxidant, anti-inflammatory, immunomodulatory, and nutritional properties, making them suitable candidates for the development of a natural health supplement. The gummies were prepared using pectin and agar as gelling agents, along with stevia as a natural sweetener, citric acid as an acidulant, and other pharmaceutical excipients to achieve the desired texture, taste, and stability. Different formulations were developed by varying the concentration of herbal extracts and excipients. The prepared formulations were evaluated for organoleptic characteristics, weight variation, pH, hardness, friability, moisture content, and stability under appropriate storage conditions. The optimized formulation demonstrated an appealing appearance, pleasant taste, smooth texture, satisfactory chewability, and acceptable physicochemical characteristics. The selected combination of herbal extracts contributed to the nutraceutical value of the formulation and provided the potential for antioxidant activity. The chewable dosage form offers improved patient compliance because of its ease of administration, portability, and palatable taste, particularly for pediatric and geriatric populations who may experience difficulty swallowing conventional tablets or capsules. The findings suggest that polyherbal nutraceutical gummies represent a promising alternative to conventional oral dosage forms. Their combination of nutritional and therapeutic benefits highlights their potential application as functional foods and herbal nutraceutical products. Further pharmacological, antioxidant, and long-term stability studies are recommended to establish their efficacy, safety, and commercial feasibility.

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INTRODUCTION

The term nutraceutical is derived from the words *nutrition* and *pharmaceutical* and refers to food or food-derived products that provide health benefits beyond basic nutrition, including the prevention and management of various diseases.[1] Nutraceuticals contain biologically active compounds that supplement the diet and contribute to maintaining health, reducing disease risk, and improving overall well-being.[1]

The concept of nutraceuticals was introduced in 1989 by Stephen L. DeFelice, founder of the Foundation for Innovation in Medicine.[2] Since then, extensive scientific research has demonstrated that dietary components significantly influence human health by regulating physiological processes and reducing the risk of chronic diseases.[3] Nutraceuticals bridge the gap between conventional foods and pharmaceutical products by providing both nutritional and therapeutic benefits.

Nutraceuticals contain a wide range of bioactive constituents, including vitamins, minerals, polyphenols, flavonoids, dietary fibre, essential fatty acids, amino acids, probiotics, and prebiotics.[4][5] These compounds exhibit antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, cardioprotective, neuroprotective, and anticancer properties. Adequate consumption of nutraceutical-rich foods has been associated with a reduced incidence of chronic disorders such as cardiovascular diseases, diabetes mellitus, obesity, neurodegenerative diseases, and certain types of cancer.[6]

Modern lifestyles characterized by unhealthy dietary habits, physical inactivity, and increased stress have contributed significantly to the growing prevalence of non-communicable diseases worldwide. According to global health reports, these diseases account for the majority of premature deaths and represent a major public health challenge.[6] Consequently, there has been increasing interest in natural products and functional foods that support disease prevention while promoting long-term health.

Several nutraceutical compounds possess strong antioxidant activity that protects cells against oxidative stress and inflammation. Natural phytochemicals, including polyphenols, carotenoids, flavonoids, and phenolic acids, have demonstrated beneficial effects in preventing cellular damage and reducing the progression of chronic diseases.[7][10] Unlike many synthetic therapeutic agents, naturally occurring bioactive compounds generally exhibit a favorable safety profile when consumed within recommended dietary limits.

Medicinal plants have been used for centuries as valuable sources of nutrition and traditional medicine. Herbs, seeds, fruits, roots, and flowers contain numerous phytochemicals that contribute to their therapeutic potential. Herbal nutraceuticals are plant-derived products developed to improve nutritional status, strengthen immunity, and support the prevention and management of acute as well as chronic disorders. [11][16]

Recent advances in nutrigenomics and nutrigenetics have further strengthened the scientific basis of nutraceutical research. These disciplines investigate the interaction between nutrients and genes, demonstrating that bioactive food components can regulate gene expression and influence metabolic pathways associated with human health.[17] Consequently, nutraceutical formulations have become increasingly important in preventive healthcare and personalized nutrition.

Among the selected herbal ingredients used in the present formulation, Lotus Seed (*Nelumbo nucifera*) is recognized as an excellent source of proteins, carbohydrates, vitamins, minerals, flavonoids, and phenolic compounds.[19] It contains important alkaloids such as neferine, nuciferine, and liensinine, which exhibit antioxidant, anti-inflammatory, antihypertensive, cardioprotective, antidiabetic, and neuroprotective activities. These bioactive constituents contribute to the therapeutic potential of lotus seeds in maintaining cardiovascular and neurological health. [19][23]

Moringa (*Moringa oleifera*) is widely regarded as one of the most nutrient-rich medicinal plants. Its leaves contain high concentrations of vitamins, minerals, essential amino acids, and natural antioxidants. Numerous studies have demonstrated its antibacterial, antiviral, antifungal, anti-inflammatory, antihyperglycemic, cardioprotective, and antioxidant properties. Additionally, moringa has been investigated for its beneficial effects in anemia, osteoporosis, dyslipidemia, metabolic syndrome, and neurodegenerative disorders such as Alzheimer's disease. [24][27]

Beetroot (*Beta vulgaris*) is an important functional food owing to its high content of betaines, phenolic acids, flavonoids, and dietary nitrates. These phytochemicals exhibit potent antioxidant and anti-inflammatory activities and have been associated with improved cardiovascular function, enhanced exercise performance, regulation of glucose metabolism, and protection against oxidative stress. Beetroot-derived betalains also possess chemoprotective and antimicrobial properties, making them valuable ingredients in nutraceutical formulations. [28][30]

Lemon (*Citrus limon*) is a rich source of vitamin C, flavonoids, limonoids, phenolic acids, terpenes, and essential oils. These bioactive compounds exhibit antioxidant, antimicrobial, anti-inflammatory, cardioprotective, antidiabetic, anti-obesity, and neuroprotective activities. Lemon-derived phytochemicals, particularly limonene and citral, have attracted considerable interest because of their therapeutic potential and widespread application in food, pharmaceutical, and nutraceutical industries. [31][32]

Papaya Leaf (*Carica papaya*) contains several biologically active constituents, including alkaloids, flavonoids, tannins, saponins, steroids, and phenolic compounds. Previous studies have reported its antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and immunomodulatory properties. Papaya leaf extract has also received considerable attention for its supportive role in dengue management and its potential to inhibit the growth of various pathogenic microorganisms. [28][12]

Among the various nutraceutical dosage forms, gummies have emerged as a highly acceptable alternative because of their attractive appearance, pleasant taste, ease of administration, portability, and improved patient compliance. Unlike conventional tablets and capsules, gummies are particularly suitable for pediatric, geriatric, and dysphagic patients who may experience difficulty swallowing solid oral dosage forms. Polyherbal gummies combine the therapeutic benefits of multiple medicinal plants with the convenience of a chewable formulation, thereby enhancing both nutritional value and consumer acceptance.

The present study was undertaken to formulate and evaluate polyherbal nutraceutical gummies containing extracts of *Nelumbo nucifera*, *Moringa oleifera*, *Beta vulgaris*, *Carica papaya*, and *Citrus limon*. The formulation was developed to provide a stable, palatable, and nutritionally enriched herbal dosage form with the potential to improve

patient compliance while delivering the health-promoting benefits of multiple medicinal plants.

2.1 Herbal Nutraceuticals

Herbal nutraceuticals are plant-based products that combine nutritional value with therapeutic potential to promote health and reduce the risk of disease. They are formulated using medicinal herbs, plant extracts, seeds, fruits, roots, flowers, or other natural ingredients that are rich in bioactive compounds. Traditional systems of medicine, including Ayurveda, Siddha, and Unani, have long utilized medicinal plants for maintaining health and managing a wide range of disorders.

In recent years, the demand for herbal nutraceuticals has increased significantly due to growing consumer awareness regarding preventive healthcare and natural products. These formulations are widely recognized for their favorable safety profile, minimal adverse effects, high patient acceptance, and potential to improve overall health. The presence of phytochemicals such as flavonoids, phenolic compounds, alkaloids, terpenoids, and essential vitamins contributes to their antioxidant, anti-inflammatory, immunomodulatory, and antimicrobial activities.

2.2 Polyherbal Formulation

Polyherbal formulations consist of two or more medicinal herbs combined in a single dosage form to achieve enhanced therapeutic efficacy through synergistic interactions. The principle of polyherbalism is based on the concept that multiple herbs acting together can produce greater pharmacological benefits than individual herbs while minimizing undesirable effects.

The use of polyherbal formulations has been extensively documented in traditional medicinal systems and is increasingly being explored in modern pharmaceutical and nutraceutical research. Such formulations offer a holistic approach to healthcare by targeting multiple physiological pathways simultaneously.

Advantages of Polyherbal Formulations

- Enhanced therapeutic efficacy through synergistic action.
- Improved pharmacological activity compared with single-herb formulations.
- Reduced dosage requirements of individual herbal components.
- Lower incidence of adverse effects and toxicity.
- Improved patient compliance and treatment acceptance.
- Broad-spectrum therapeutic potential against multiple health conditions.

The integration of multiple herbal ingredients in a single formulation enhances its nutritional and medicinal value, making polyherbal products suitable for preventive as well as supportive healthcare applications.

2.3 Gummies as a Drug Delivery System

Gummies are soft, chewable oral dosage forms that have gained considerable popularity in both the pharmaceutical and nutraceutical industries. They are commonly prepared using gelling agents such as pectin or gelatin, together with sweeteners, flavoring agents, colorants, and active pharmaceutical or herbal ingredients. Compared with conventional tablets and capsules, gummies provide improved palatability and greater patient convenience.

Nutraceutical gummies have emerged as an attractive dosage form because they combine the therapeutic benefits of active ingredients with the

sensory appeal of confectionery products. Their pleasant taste, ease of administration, and portability significantly improve patient adherence, particularly among pediatric, geriatric, and dysphagic populations.

Benefits of Nutraceutical Gummies

- Improved patient compliance and adherence.
- Pleasant taste, texture, and appearance.
- Easy administration without the need for water.
- Suitable for children, elderly individuals, and patients with swallowing difficulties.
- Accurate and convenient dosing.
- Enhanced consumer acceptance due to their chewable nature.

Gummies can be formulated using natural sweeteners, fruit flavors, herbal extracts, vitamins, minerals, and other functional ingredients, making them an effective platform for delivering nutraceutical compounds.

2.4 Advantages of Herbal Gummies

Herbal gummies combine the health-promoting properties of medicinal plants with the convenience of a chewable dosage form. Their attractive sensory characteristics and ease of consumption have contributed to their increasing popularity among consumers seeking natural healthcare products.

Advantages of Herbal Gummies

1. Improved palatability and pleasant taste.
2. Easy to chew and swallow without water.
3. Enhanced patient acceptance and compliance.
4. Good physical stability during storage.
5. Convenient and portable dosage form.
6. Improved adherence to long-term supplementation.
7. Attractive formulation suitable for routine use.
8. Appropriate for pediatric, geriatric, and adult populations.
9. Ability to incorporate multiple herbal ingredients in a single dosage form.
10. Increased market acceptance as a functional food and nutraceutical product.

2.5 Selected Herbal Ingredients

2.5.1 Lotus Seed (*Nelumbo nucifera*)

Lotus seed is a nutrient-rich botanical widely recognized for its medicinal and nutritional value. It contains proteins, carbohydrates, essential minerals, vitamins, flavonoids, and phenolic compounds that contribute to its antioxidant and health-promoting properties. Bioactive alkaloids such as neferine, nuciferine, and liensinine have been reported to exhibit antioxidant, anti-inflammatory, cardioprotective, neuroprotective, and antihypertensive activities. Owing to its rich phytochemical composition, lotus seed is considered an important functional ingredient in nutraceutical formulations aimed at promoting overall health and well-being.

2.5.2 Moringa (*Moringa oleifera*)

Moringa oleifera is widely recognized as a highly nutritious medicinal plant because of its exceptional content of vitamins, minerals, amino acids, proteins, and natural antioxidants. The leaves are rich in bioactive compounds including flavonoids, phenolic acids, and carotenoids, which contribute to their antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties. Moringa has been extensively investigated for its potential role in enhancing immunity, improving nutritional status, supporting cardiovascular health, and protecting against oxidative stress.

2.5.3 Papaya Leaf (*Carica papaya*)

Papaya leaf contains numerous bioactive constituents, including flavonoids, alkaloids, papain, tannins, saponins, and phenolic compounds. These phytochemicals are associated with antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory activities. Papaya leaf extract has attracted considerable scientific interest for its supportive role in maintaining platelet count during dengue infection and for its potential to enhance immune function. Its broad therapeutic profile makes it a valuable ingredient in herbal nutraceutical formulations.

2.5.4 Beetroot (*Beta vulgaris*)

Beetroot is an excellent source of dietary nitrates, betalains, flavonoids, phenolic compounds, folic acid, iron, vitamins, and essential minerals. These bioactive constituents exhibit potent antioxidant and anti-inflammatory properties that contribute to cardiovascular health, improved blood circulation, enhanced exercise performance, and regulation of oxidative stress. Beetroot is also recognized for its nutritional value and its ability to support energy metabolism and overall physiological well-being.

2.5.5 Lemon (*Citrus limon*)

Lemon is a rich source of vitamin C, flavonoids, phenolic compounds, limonoids, citral, and essential oils. These phytochemicals possess antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory activities that contribute to overall health promotion. In nutraceutical formulations, lemon not only enhances flavor and aroma but also improves consumer acceptability while contributing additional antioxidant and nutritional benefits.

3. DRUG PROFILE

3.1 Lotus Seed (*Nelumbo nucifera*)

Biological Source

Lotus seeds are the dried mature seeds of *Nelumbo nucifera* Gaertn., belonging to the family **Nelumbonaceae**.

Chemical Constituents

- Proteins
- Carbohydrates
- Flavonoids
- Alkaloids (Neferine, Nuciferine, Liensinine)
- Phenolic compounds
- Calcium, Phosphorus, Magnesium, and Potassium

Uses

- Antioxidant
- Cardioprotective
- Neuroprotective
- Nutritional supplement
- Digestive health support
- General wellness promotion

Mechanism of Action

Lotus seeds are rich in phenolic compounds and bioactive alkaloids that scavenge free radicals, reduce oxidative stress, and inhibit inflammatory mediators. These constituents contribute to cardiovascular protection, neuronal health, and overall nutritional support.

Fig 1 - Lotus Seed (*Nelumbo nucifera*)

3.2 Moringa (*Moringa oleifera*)

Biological Source

Moringa consists of the dried leaves of *Moringa oleifera* Lam., belonging to the family **Moringaceae**.

Chemical Constituents

- Vitamin A
- Vitamin C
- Vitamin E
- Calcium
- Iron
- Potassium
- Flavonoids
- Phenolic compounds
- Essential amino acids

Uses

- Immunity enhancement
- Antioxidant
- Anti-inflammatory
- Nutritional supplementation
- Antidiabetic support
- Cardiovascular health promotion

Mechanism of Action

Moringa oleifera contains vitamins, minerals, flavonoids, and phenolic compounds that neutralize reactive oxygen species and reduce oxidative stress. These phytochemicals also modulate inflammatory pathways, enhance immune function, and improve nutritional status.

Fig-2- Moringa (*Moringa oleifera*)

3.3 Papaya Leaf (*Carica papaya*)

Biological Source

Papaya leaves are obtained from *Carica papaya* L., belonging to the family **Caricaceae**.

Chemical Constituents

- Papain
- Flavonoids
- Alkaloids
- Phenolic compounds
- Tannins
- Saponins
- Vitamins A and C

Uses

- Immunity support
- Antioxidant
- Platelet-supportive therapy
- Digestive aid
- Antimicrobial activity

Mechanism of Action

Papaya leaf contains bioactive phytochemicals that exhibit antioxidant and immunomodulatory activities by reducing oxidative stress and enhancing the body's natural defense mechanisms. The enzyme papain also supports digestive function by facilitating protein digestion.

Fig 3- Papaya Leaf (*Carica papaya*)

3.4 Beetroot (*Beta vulgaris*)

Biological Source

Beetroot is obtained from the edible root of *Beta vulgaris* L., belonging to the family **Amaranthaceae**.

Chemical Constituents

- Betalains
- Dietary nitrates
- Folic acid
- Iron
- Potassium
- Vitamin C
- Phenolic compounds
- Flavonoids

Uses

- Supports cardiovascular health
- Antioxidant
- Improves blood circulation
- Enhances exercise performance
- Nutritional supplementation

Mechanism of Action

Beetroot is rich in dietary nitrates, which are converted into nitric oxide within the body, promoting vasodilation and improving blood circulation. Its betalains and phenolic compounds exhibit potent antioxidant and anti-inflammatory activities that help reduce oxidative stress and support cardiovascular health.

Fig 4- Beetroot (*Beta vulgaris*)

3.5 Lemon (*Citrus limon*)

Biological Source

Lemon is the fresh fruit of *Citrus limon* (L.) Osbeck, belonging to the family **Rutaceae**.

Chemical Constituents

- Vitamin C (Ascorbic acid)
- Citric acid
- Flavonoids (Hesperidin, Eriocitrin, Diosmin)
- Essential oils (Limonene, Citral)
- Phenolic compounds

Uses

- Antioxidant
- Immunity enhancement
- Antimicrobial activity
- Flavoring and acidifying agent
- Nutritional supplementation

Mechanism of Action

The bioactive constituents of lemon, particularly vitamin C, flavonoids, and essential oils, protect cells against oxidative damage by scavenging free radicals. These compounds also contribute to immune support, exhibit antimicrobial activity, and improve the sensory characteristics of nutraceutical formulations.

Fig 5- Lemon (*Citrus limon*)

5. AIM AND OBJECTIVES

Aim

To formulate and evaluate polyherbal nutraceutical gummies incorporating selected medicinal plant extracts with the objective of developing a stable, palatable, and patient-friendly nutraceutical dosage form possessing nutritional and health-promoting properties.

Objectives

The objectives of the present study were:

1. To formulate polyherbal nutraceutical gummies using selected medicinal plant extracts.
2. To evaluate the compatibility of herbal ingredients with the selected pharmaceutical excipients.
3. To optimize the formulation by varying the concentration of gelling agents and excipients.
4. To evaluate the organoleptic characteristics, including colour, appearance, odour, taste, texture, and chewability.
5. To determine the physicochemical properties of the formulated gummies, including weight variation, pH, hardness, friability, and moisture content.
6. To assess the stability of the optimized formulation under appropriate storage conditions.
7. To develop a nutritionally enriched, stable, and patient-compliant herbal nutraceutical gummy suitable for routine health supplementation.

Formulation of Polyherbal Nutraceutical Gummies

Three different formulations were prepared by varying the concentration of agar and pectin while maintaining the quantities of herbal extracts constant. Each formulation was prepared to obtain **15 gummies**, each weighing approximately **5 g**, giving a total batch weight of **75 g**.

Tablw 1 - Formulation of Polyherbal Nutraceutical Gummies

Ingredients	Batch F1 (g)	Batch F2 (g)	Batch F3 (Optimized) (g)	Functional Role
Agar	2.0	2.4	2.8	Gelling agent and firmness enhancer

Pectin	1.0	1.4	1.8	Texture modifier and chewability
Sorbitol Syrup	12	13	14	Humectant and softening agent
Glucose Syrup	10	11	12	Sweetener and anti-crystallizing agent
Stevia Leaf Extract	0.20	0.22	0.25	Natural sweetener
Citric Acid	0.35	0.40	0.45	pH adjustment and flavour enhancement
Sodium Benzoate	0.08	0.08	0.08	Preservative
Moringa Leaf Extract	1.5	1.5	1.5	Active herbal ingredient
Papaya Leaf Extract	1.5	1.5	1.5	Active herbal ingredient
Lotus Seed Extract	1.0	1.2	1.2	Active herbal ingredient
Beetroot Extract	4.0	5.0	6.0	Natural colourant and antioxidant source
Lemon Extract	0.5	0.6	0.7	Flavouring agent
Purified Water	q.s. to 75 g	q.s. to 75 g	q.s. to 75 g	Vehicle

Characteristics of Trial Formulations

Batch F1

- Soft texture with moderate chewability.
- Lower gel strength because of reduced agar concentration.
- Suitable for preliminary formulation studies.

Batch F2

- Improved texture and elasticity.
- Better structural integrity and shape retention.
- Enhanced mouthfeel and consumer acceptability.

Batch F3 (Optimized Formulation)

- Firm yet easily chewable texture.
- Superior thermal stability and resistance to softening.
- Excellent mould release characteristics.
- Uniform dark-red appearance due to beetroot extract.
- Selected as the optimized formulation based on its overall physical characteristics and suitability for further evaluation.

8. RESULTS AND DISCUSSION

The formulated polyherbal nutraceutical gummies were evaluated for their organoleptic characteristics, physicochemical properties, and stability to assess the quality and suitability of the developed formulation. The selected evaluation parameters included organoleptic properties, weight variation, pH, texture, friability, disintegration time, moisture content, stability, herbal content uniformity, and syneresis. These tests were performed to ensure product quality, consistency, and patient acceptability.

1. Organoleptic Evaluation

Objective

To assess the sensory characteristics and overall consumer acceptability of the formulated gummies.

Evaluation Parameters

- Colour
- Odour
- Taste
- Shape
- Texture

Table 2 - Acceptance Criteria

Parameter	Acceptance Criteria
Colour	Uniform dark red
Odour	Pleasant characteristic herbal-fruity aroma
Taste	Sweet with mild sourness
Shape	Uniform hemispherical shape
Texture	Firm, smooth, non-sticky, and chewy

Discussion

Organoleptic evaluation is an important quality control parameter for chewable nutraceutical formulations. A desirable colour, pleasant aroma, acceptable taste, and appropriate texture improve consumer acceptance and patient compliance. The incorporation of beetroot extract contributed to the characteristic dark-red colour, while lemon extract enhanced flavour and reduced the herbal aftertaste.

2. Weight Variation Test

Objective

To evaluate the uniformity of individual gummy units and ensure consistent dosing.

Procedure

Ten gummies were randomly selected and weighed individually using a calibrated digital analytical balance. The average weight was calculated and compared with the individual weights.

Formula

$$\text{Average Weight} = \frac{\text{Total Weight}}{\text{Number of Gummies}}$$

Acceptance Criteria

- Individual gummies should exhibit minimal variation from the average weight.
- The average weight should be approximately **5 g per gummy**.

Discussion

Uniform weight indicates consistent mould filling, proper mixing of ingredients, and reproducible manufacturing conditions. Weight variation is a critical quality parameter for ensuring dose uniformity in nutraceutical formulations.

3. pH Determination

Objective

To determine the acidity of the gummy formulation and evaluate its suitability for product stability and palatability.

Procedure

One gummy was dispersed in 10 mL of distilled water, and the pH was measured using a calibrated digital pH meter.

Table 3- Acceptance Criteria

Parameter	Acceptance Range
pH	3.5–4.5

Discussion

Maintaining a mildly acidic pH enhances flavour, improves microbiological stability, and contributes to the effectiveness of preservatives such as sodium benzoate. It also supports the physical stability of the gummy matrix during storage.

4 Texture and Firmness Evaluation

Objective

To assess the mechanical properties and chewability of the formulated gummies.

Table 4 - Evaluation Criteria

Parameter	Acceptance Criteria
Firmness	Moderate to firm
Elasticity	Good
Stickiness	Absent or minimal

Discussion

Texture is influenced primarily by the concentration of agar and pectin. A balanced combination of these gelling agents provides adequate firmness while maintaining elasticity and chewability, thereby improving consumer acceptability.

5 Friability (Surface Integrity Test)

Objective

To evaluate the resistance of the gummies to surface damage during handling and storage.

Procedure

The gummies were placed in a closed container and gently shaken. Their surface was examined for cracks, deformation, or breakage.

Acceptance Criteria

- No cracking
- No surface damage
- Shape retained

Discussion

Good surface integrity indicates sufficient mechanical strength and minimizes product loss during packaging, transportation, and storage.

6 Disintegration Test

Objective

To determine the time required for the gummies to soften and disintegrate under physiological conditions.

Procedure

Each gummy was placed in phosphate buffer or distilled water maintained at **37 ± 0.5°C**, and the disintegration time was recorded.

Table 5- Acceptance Criteria

Parameter	Acceptance Range
Disintegration Time	20–40 minutes

Discussion

An appropriate disintegration time ensures gradual release of herbal constituents while maintaining the desirable chewable characteristics expected of nutraceutical gummies.

7 Moisture Content

Objective

To estimate the moisture level of the formulation, which directly influences texture, stability, and microbial quality.

Procedure

The gummies were weighed before and after drying in a hot air oven until a constant weight was achieved.

Formula

$$\text{Moisture Content (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where:

- **W_1** = Initial weight
- **W_2** = Final dried weight

Table 6- Acceptance Criteria

Parameter	Acceptance Range
Moisture Content	12–20%

Discussion

Maintaining an appropriate moisture content helps preserve the soft and chewy texture of the gummies while reducing the risk of microbial spoilage and extending product shelf life.

8 Stability Study

Objective

To evaluate the physical stability of the gummies during storage.

Table 7- Storage Conditions

Storage Condition	Study Duration
Room Temperature	15–30 days
Refrigerated (2–8°C)	15–30 days

Evaluation Parameters

- Colour
- Odour
- Texture
- Stickiness
- Shape retention

Acceptance Criteria

- No significant change in appearance.
- No fungal or microbial growth.
- No excessive stickiness.
- Texture retained throughout storage.

Discussion

Stability studies provide information regarding the suitability of the formulation for storage and distribution. Proper selection of preservatives and packaging materials contributes significantly to maintaining product quality throughout the storage period.

9 Herbal Content Uniformity

Objective

To evaluate the uniform distribution of herbal extracts throughout the gummy formulation.

Procedure

The gummy sample was crushed, dispersed in a suitable solvent, and visually examined for uniform dispersion. Spectrophotometric analysis may be performed where analytical facilities are available.

Acceptance Criteria

- Uniform dispersion of herbal extracts.
- No visible separation or sedimentation.

Discussion

Uniform distribution of herbal constituents ensures consistent nutritional composition and dose uniformity among individual gummies.

10 Syneresis Test

Objective

To evaluate the tendency of the gel matrix to release water during storage.

Procedure

The formulated gummies were stored at room temperature and periodically observed for any evidence of water separation.

Acceptance Criteria

- No visible water leakage.
- Stable gel structure throughout storage.

8.2 DISCUSSION

The present study was undertaken to formulate and evaluate polyherbal nutraceutical gummies containing extracts of *Nelumbo nucifera* (Lotus Seed), *Moringa oleifera* (Moringa), *Carica papaya* (Papaya Leaf), *Beta vulgaris* (Beetroot), and *Citrus limon* (Lemon). The formulation was successfully developed using agar and pectin as natural gelling agents, producing a stable and palatable chewable dosage form suitable for nutraceutical applications.

The selected herbal ingredients were incorporated to provide complementary nutritional and therapeutic benefits because of their well-documented antioxidant, anti-inflammatory, immunomodulatory, and health-promoting properties. The combination of multiple medicinal plant extracts was intended to enhance the overall nutraceutical value of the formulation through a polyherbal approach.

The concentration of agar and pectin played a crucial role in determining the physicochemical characteristics of the gummies, particularly texture, firmness, elasticity, and chewability. Appropriate optimization of these gelling agents contributed to the development of gummies with

desirable sensory characteristics and satisfactory structural integrity.

Among the three trial formulations, Batch F3 exhibited the most desirable physical characteristics, including improved texture, pleasant taste, attractive appearance, enhanced stability, and better overall acceptability. The increased concentration of agar and pectin in this formulation resulted in improved gel strength and superior resistance to deformation while maintaining adequate chewability.

Compared with conventional oral dosage forms such as tablets and capsules, the developed gummies offer several practical advantages, including improved palatability, ease of administration, portability, and enhanced patient compliance. These characteristics make the formulation particularly suitable for pediatric, geriatric, and dysphagic patients.

Overall, the findings indicate that polyherbal nutraceutical gummies represent a promising dosage form for delivering plant-derived bioactive compounds. The conclusions regarding formulation performance should be interpreted in conjunction with the actual experimental observations obtained during laboratory evaluation.

9. CONCLUSION

The present study focused on the formulation and evaluation of polyherbal nutraceutical gummies incorporating extracts of *Nelumbo nucifera* (Lotus Seed), *Moringa oleifera* (Moringa), *Carica papaya* (Papaya Leaf), *Beta vulgaris* (Beetroot), and *Citrus limon* (Lemon). The formulation was successfully developed using pectin and agar as natural gelling agents to produce a stable, palatable, and patient-friendly chewable nutraceutical dosage form.

The prepared gummies demonstrated satisfactory organoleptic characteristics, including an attractive appearance, pleasant taste, desirable texture, and good chewability. The physicochemical evaluation indicated acceptable quality attributes such as uniform weight, appropriate pH, suitable firmness, satisfactory moisture content, and good physical stability. Among the prepared formulations, Batch F3 exhibited the most favorable overall characteristics and was selected as the optimized formulation based on its texture, stability, appearance, and consumer acceptability.

The incorporation of selected herbal extracts provided a combination of nutritionally valuable phytochemicals with reported antioxidant, anti-inflammatory, and immunomodulatory properties, supporting the potential use of the formulation as a functional nutraceutical product. The chewable dosage form offers practical advantages over conventional tablets and capsules by improving palatability, ease of administration, portability, and patient compliance, particularly among pediatric, geriatric, and individuals with swallowing difficulties.

Overall, the findings of the present investigation suggest that polyherbal nutraceutical gummies represent a promising platform for delivering herbal bioactive ingredients in a convenient and consumer-friendly dosage form. However, additional investigations, including phytochemical standardization, long-term stability studies, microbial quality assessment, pharmacological evaluation, and well-designed clinical studies, are required to further establish the safety, efficacy, and commercial applicability of the developed formulation.

The present work provides a scientific foundation for the future development of polyherbal nutraceutical gummies and highlights their

potential application in preventive healthcare, nutritional supplementation, and wellness management within the pharmaceutical and nutraceutical industries.

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