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Research Article

**HERBAL-PROBIOTIC BASED NOVEL FORMULATION FOR
GUT MICROBIOTA MODULATION IN IBS AND IBD****Dr. R. H. Kale¹, Dr. R. R. Pagore², Dr. A. D. Gattani³, Prof. S. N. Gadekar⁴**¹Department of Pharmacognosy, PRMSS Anuradha College of Pharmacy, Chikhli, Buldhana, Maharashtra, India²Department of Chemistry, Karmayogi Tatyasaheb Bondre Institute of Pharmacy, Chikhli, Buldhana, Maharashtra, India³Department of Pharmaceutics, PRMSS Anuradha College of Pharmacy, Chikhli, Buldhana, Maharashtra, India⁴Department of Pharmaceutics, PRMSS Anuradha College of Pharmacy, Chikhli, Buldhana, Maharashtra, India**Abstract:**

The present study was carried out to develop and evaluate a herbal-probiotic syrup formulation for gut microbiota modulation in IBS and IBD. Medicinal herbs including Aloe vera, Curcuma longa, Mentha piperita, Zingiber officinale, and Glycyrrhiza glabra were selected for formulation development due to their anti-inflammatory and gastroprotective properties. Hydroalcoholic extracts of the herbs were combined with probiotic strains Lactobacillus acidophilus and Bifidobacterium bifidum to prepare five syrup formulations. The prepared formulations were evaluated for physicochemical properties, probiotic viability, antioxidant activity, anti-inflammatory activity, and stability. Among all formulations, F3 showed better stability, probiotic survival, and biological activity. The study suggests that herbal-probiotic syrup may serve as a promising natural therapeutic approach for gut microbiota restoration and management of IBS and IBD.

Keywords: Herbal-Probiotic Syrup, Gut Microbiota, IBS, IBD, Probiotics, Antioxidant Activity, Anti-inflammatory Activity, Gastrointestinal Disorders, Polyherbal Formulation, Synbiotic Therapy

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INTRODUCTION:

Gastrointestinal Health and Gut Microbiota

The human gastrointestinal tract contains a diverse population of microorganisms collectively known as gut microbiota. These microorganisms include beneficial bacteria, fungi, and other microbes that play an important role in maintaining intestinal health and normal physiological functions. Gut microbiota contributes to digestion, nutrient absorption, vitamin synthesis, immune regulation, and protection against harmful pathogens. A healthy intestinal microbial balance is essential for maintaining gastrointestinal homeostasis and overall health.¹

Disturbance in gut microbial balance, commonly referred to as dysbiosis, is associated with several gastrointestinal disorders such as Irritable Bowel Syndrome (IBS), Inflammatory Bowel Disease (IBD), diarrhea, constipation, obesity, metabolic disorders, and colorectal cancer. Alteration in microbial composition can lead to intestinal inflammation, oxidative stress, impaired barrier function, and abnormal immune responses. Therefore, modulation of gut microbiota has become an important therapeutic strategy for management of gastrointestinal diseases.²

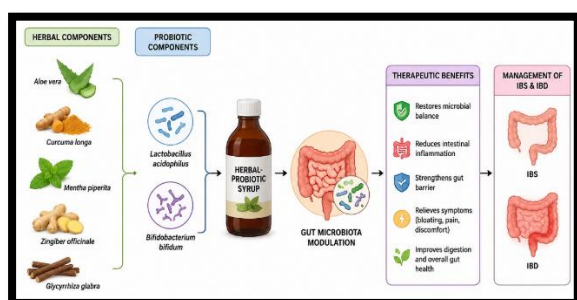


Figure 1: Herbal-Probiotic Approach for Gut Microbiota Modulation in IBS and IBD

Irritable Bowel Syndrome (IBS)

Irritable Bowel Syndrome is a chronic functional gastrointestinal disorder characterized by abdominal pain, bloating, diarrhea, constipation, and altered bowel habits. IBS affects a large population worldwide and significantly decreases quality of life of affected patients. The exact cause of IBS is not fully understood, but several factors such as altered gut microbiota, intestinal hypersensitivity, stress, dietary factors, and abnormal gastrointestinal motility are believed to contribute to development of the disorder.³

IBS is commonly classified into constipation-predominant IBS, diarrhea-predominant IBS, and mixed IBS. Patients suffering from IBS often experience recurrent abdominal discomfort,

flatulence, irregular bowel movements, and digestive disturbances. Conventional treatment mainly focuses on symptomatic relief using antispasmodics, laxatives, antidiarrheal agents, and dietary modifications. However, prolonged use of synthetic drugs may produce undesirable side effects, creating demand for safer natural therapeutic alternatives.⁴

Inflammatory Bowel Disease (IBD)

Inflammatory Bowel Disease is a chronic inflammatory condition of the gastrointestinal tract mainly comprising Crohn's disease and ulcerative colitis. IBD is associated with intestinal inflammation, mucosal ulceration, diarrhea, abdominal pain, rectal bleeding, fatigue, and weight loss. The incidence of IBD has increased globally due to changes in dietary habits, environmental factors, stress, and microbial imbalance.⁵

The pathogenesis of IBD involves complex interaction between genetic predisposition, immune dysfunction, oxidative stress, and altered gut microbiota. Dysbiosis can activate inflammatory pathways leading to chronic intestinal inflammation and tissue damage. Current treatment approaches include corticosteroids, immunosuppressants, anti-inflammatory drugs, and biological therapies. Although these medications help reduce inflammation, long-term use may result in adverse effects and increased treatment cost. Therefore, herbal medicines and probiotics are being explored as safer and more effective alternatives for management of IBD.⁶

Role of Herbal Medicines in Gastrointestinal Disorders

Medicinal plants have been used traditionally for treatment of digestive disorders since ancient times. Herbal medicines contain various bioactive phytoconstituents such as flavonoids, alkaloids, tannins, terpenoids, glycosides, and phenolic compounds which possess anti-inflammatory, antioxidant, antimicrobial, and gastroprotective activities. Herbal drugs are considered safer, economical, and associated with fewer side effects than synthetic medications.⁷

Several medicinal plants have demonstrated beneficial effects in management of IBS and IBD through modulation of intestinal inflammation, reduction of oxidative stress, improvement of mucosal healing, and restoration of gut microbial balance. Plants such as Aloe vera, Curcuma longa, Mentha piperita, Zingiber officinale, and Glycyrrhiza glabra have shown promising therapeutic effects in gastrointestinal disorders. These herbs contain phytochemicals capable of

reducing intestinal inflammation, improving digestion, and protecting gastrointestinal mucosa.⁸

Importance of Probiotics in Gut Health

Probiotics are live beneficial microorganisms which provide health benefits when administered in adequate amounts. Common probiotic organisms include *Lactobacillus* species, *Bifidobacterium* species, and *Saccharomyces* species. Probiotics help maintain intestinal microbial balance by inhibiting growth of pathogenic microorganisms and promoting growth of beneficial bacteria.⁹

Probiotics improve gastrointestinal health through enhancement of intestinal barrier function, modulation of immune response, reduction of inflammation, and production of antimicrobial substances. They also help improve digestion, nutrient absorption, and bowel regularity. Several clinical studies have reported beneficial effects of probiotics in management of IBS and IBD by reducing abdominal pain, bloating, diarrhea, and intestinal inflammation.

The combination of probiotics with herbal medicines may produce synergistic therapeutic effects through simultaneous modulation of gut microbiota and reduction of intestinal inflammation. Therefore, development of herbal-probiotic formulations has become an emerging area in gastrointestinal research.¹⁰

Concept of Herbal-Probiotic Novel Formulation

A herbal-probiotic formulation combines medicinal plant extracts with beneficial probiotic microorganisms to provide enhanced therapeutic effects for gastrointestinal disorders. Such formulations may help restore healthy gut microbiota, improve intestinal barrier function, reduce oxidative stress, and decrease intestinal inflammation.¹¹

Herbal constituents provide antioxidant, anti-inflammatory, antimicrobial, and gastroprotective activities, while probiotics improve microbial balance and intestinal immunity. The combined effect may enhance treatment effectiveness and improve patient compliance. Novel herbal-probiotic formulations are considered promising alternatives for management of IBS and IBD due to their natural origin and lower risk of side effects.¹²

EXPERIMENTAL WORK

Selection of Herbal Ingredients

The herbal ingredients selected for the present investigation were based on their traditional use, therapeutic importance, and reported pharmacological activities related to gastrointestinal disorders. Medicinal plants possessing anti-inflammatory, antioxidant, antimicrobial, mucoprotective, and digestive properties were selected for preparation of herbal-probiotic syrup

intended for gut microbiota modulation in IBS and IBD.¹³

The selected herbs included *Aloe vera*, *Curcuma longa*, *Mentha piperita*, *Zingiber officinale*, and *Glycyrrhiza glabra*. These medicinal plants are widely known for their beneficial effects in intestinal inflammation, abdominal discomfort, indigestion, bloating, and gastrointestinal irritation.¹⁴

The probiotics selected for the study included *Lactobacillus acidophilus* and *Bifidobacterium bifidum* because of their important role in restoration of gut microbial balance and improvement of intestinal health.¹⁵

Procurement and Authentication of Raw Materials

The medicinal plant materials were procured from authenticated herbal suppliers and local medicinal plant sources. The collected herbal materials were identified and authenticated by a pharmacognosy expert using organoleptic and botanical characteristics. Healthy and contamination-free plant materials were selected for experimental studies.

The probiotic cultures were obtained from certified microbial culture laboratories and stored under refrigerated conditions to preserve microbial viability. All chemicals and reagents used during experimental work were of analytical grade.¹⁶

Processing of Herbal Materials

The collected plant materials were washed thoroughly with distilled water to remove dirt and foreign particles. The materials were shade dried at room temperature for several days to preserve thermolabile phytoconstituents and prevent degradation of active compounds.¹⁷

After drying, the herbal materials were pulverized separately using mechanical grinder to obtain coarse powder. The powdered materials were passed through sieve no. 40 to achieve uniform particle size distribution and stored in airtight containers until further use.¹⁸

Table 1: Organoleptic Characteristics of Selected Herbal Powders

Sr. No.	Herbal Powder	Color	Odor	Taste
1	Aloe vera	Light brown	Characteristic	Slightly bitter
2	Curcuma longa	Yellow	Aromatic	Bitter
3	Mentha piperita	Greenish	Mint odor	Cooling
4	Zingiber officinale	Pale yellow	Pungent	Spicy

5	Glycyrrhiza glabra	Brown	Sweet odor	Sweet
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Preparation of Herbal Extracts

The powdered herbal materials were subjected to hydroalcoholic extraction using maceration technique. Each powdered herb was soaked separately in hydroalcoholic solvent containing ethanol and distilled water for 72 hours with intermittent shaking.¹⁹

The extraction process allows solvent penetration into plant tissues and dissolution of phytoconstituents present in the herbal materials. Occasional stirring improves extraction efficiency and promotes release of active compounds into solvent medium.

After completion of extraction, the mixtures were filtered using muslin cloth followed by Whatman filter paper. The filtrates obtained were concentrated using water bath at controlled temperature until semisolid extracts were obtained. The extracts were stored in airtight containers under refrigerated conditions.²⁰

Preparation of Polyherbal Blend

The concentrated extracts of selected medicinal plants were weighed accurately and mixed uniformly to prepare polyherbal extract blend. Geometric mixing method was used to ensure uniform distribution of herbal extracts throughout the formulation.²¹

The combination of herbal extracts was selected to provide synergistic anti-inflammatory, antioxidant, digestive, and gastroprotective effects beneficial for IBS and IBD management.²²

Table 2: Composition of Polyherbal Extract Blend

Herbal Extract	Quantity (%)
Aloe vera extract	25
Curcuma longa extract	20
Mentha piperita extract	15
Zingiber officinale extract	20
Glycyrrhiza glabra extract	20

Preparation of Syrup Base

The syrup base was prepared using purified water, sucrose syrup, glycerin, and suitable stabilizing agents. Sucrose was dissolved in purified water with gentle heating to obtain clear syrup solution. Glycerin was added to improve viscosity and mouth feel of the formulation.

The prepared syrup base was cooled to room temperature before incorporation of herbal extracts and probiotics to avoid damage to probiotic organisms.²³

Incorporation of Probiotics

The probiotic cultures *Lactobacillus acidophilus* and *Bifidobacterium bifidum* were incorporated carefully into the cooled syrup base under aseptic conditions. Temperature was maintained below critical level to preserve viability of probiotic organisms.

The probiotic cultures were mixed gently to avoid mechanical damage and ensure uniform distribution throughout the formulation.²⁴

Preparation of Herbal-Probiotic Syrup Formulations

Five formulation batches were prepared using different concentrations of herbal extracts and probiotics to optimize formulation characteristics and biological activity. The formulations were designated as F1, F2, F3, F4, and F5.²⁵

Table 3: Formulation Composition of Herbal-Probiotic Syrup Batches

Ingredients	F1 (%)	F2 (%)	F3 (%)	F4 (%)	F5 (%)
Polyherbal extract blend	20	25	30	35	40
<i>Lactobacillus acidophilus</i>	5	5	5	5	5
<i>Bifidobacterium bifidum</i>	5	5	5	5	5
Sucrose syrup	55	50	45	40	35
Glycerin	10	10	10	10	10
Preservative	2	2	2	2	2
Flavoring agent	3	3	3	3	3

Evaluation of Herbal-Probiotic Syrup

The prepared syrup formulations were evaluated for various physicochemical and microbiological parameters to determine quality, stability, and suitability of formulation.

Organoleptic Evaluation

The syrup formulations were examined visually for color, odor, taste, appearance, and homogeneity.

Organoleptic evaluation is important for patient acceptability and overall formulation quality.²⁶

pH Determination

The pH of syrup formulations was determined using digital pH meter. Proper pH is important for formulation stability, probiotic viability, and patient acceptability.

Viscosity Study

Viscosity evaluation was carried out using Brookfield viscometer. Appropriate viscosity helps improve mouth feel, stability, and uniformity of syrup formulation.²⁷

Specific Gravity

Specific gravity of syrup formulations was determined using specific gravity bottle. The study helps evaluate consistency and concentration of syrup formulations.

Sedimentation Study

Sedimentation behavior of syrup formulations was observed visually during storage. Absence of sedimentation indicates good formulation stability and uniform distribution of ingredients.²⁸

Probiotic Viability Study

Viability of probiotic organisms was evaluated using microbial culture methods. The syrup formulations were diluted using sterile saline solution and inoculated on suitable culture media.

The inoculated plates were incubated under controlled laboratory conditions and colony-forming units were counted. The viability study confirmed survival of probiotics within the syrup formulations.²⁹

Antioxidant Activity Study

The antioxidant activity of syrup formulations was evaluated using DPPH free radical scavenging assay. The formulations exhibited concentration-dependent antioxidant activity due to presence of flavonoids, phenolics, curcuminoids, and probiotic metabolites.

Anti-inflammatory Evaluation

The anti-inflammatory activity of herbal-probiotic syrup was evaluated using protein denaturation inhibition method. The formulations showed significant inhibition of protein denaturation indicating anti-inflammatory potential.

Stability Study

The prepared syrup formulations were subjected to short-term stability studies under controlled temperature and humidity conditions. During stability study, the formulations were evaluated

periodically for color, odor, pH, sedimentation, probiotic viability, and overall appearance.

The formulations remained stable throughout the study period without significant changes in physicochemical properties. F3 formulation exhibited better stability and probiotic viability compared to other batches.³⁰

The herbal-probiotic syrup formulation developed during the present study represents a novel synbiotic approach for management of IBS and IBD. The combination of medicinal herbs and probiotics may help restore healthy gut microbiota, reduce intestinal inflammation, improve digestion, and enhance intestinal mucosal protection.

The liquid syrup dosage form provides better patient compliance, easier administration, improved dispersion of probiotics, and enhanced gastrointestinal absorption compared to solid dosage forms. The study indicates that herbal-probiotic syrup may serve as a promising natural therapeutic approach for gastrointestinal disorders associated with gut microbiota imbalance.³¹

RESULTS AND DISCUSSION:

The present investigation was carried out to develop and evaluate a herbal-probiotic syrup formulation intended for gut microbiota modulation in IBS and IBD. The prepared formulations were evaluated for physicochemical characteristics, probiotic viability, antioxidant activity, anti-inflammatory activity, and formulation stability. The findings obtained during the study confirmed that the combination of medicinal herbs and probiotics produced satisfactory pharmaceutical and biological properties suitable for gastrointestinal health management.

Organoleptic Characteristics of Herbal Powders

The selected herbal powders showed characteristic organoleptic properties including color, odor, taste, and texture. Proper organoleptic characteristics indicate purity and quality of crude herbal materials used in formulation development.

Aloe vera powder showed light brown color with characteristic odor and slightly bitter taste. Curcuma longa powder exhibited yellow color and aromatic odor due to presence of curcuminoids and volatile oils. Mentha piperita powder possessed mint odor and cooling taste because of menthol constituents. The characteristic odor and taste observed in herbal powders indicate presence of volatile phytoconstituents and active secondary metabolites responsible for medicinal activities.

Table 4: Organoleptic Characteristics of Herbal Powders

Herbal Powder	Color	Odor	Taste
Aloe vera	Light brown	Characteristic	Slightly bitter
Curcuma longa	Yellow	Aromatic	Bitter
Mentha piperita	Greenish	Mint odor	Cooling
Zingiber officinale	Pale yellow	Pungent	Spicy
Glycyrrhiza glabra	Brown	Sweet odor	Sweet

The herbal materials were found suitable for formulation development because no fungal contamination, moisture-related spoilage, or abnormal odor was observed during examination.

Extraction and Polyherbal Blend Characteristics

The hydroalcoholic extraction method produced satisfactory yield of concentrated herbal extracts. The extracts appeared dark brown in color with characteristic odor and semisolid consistency. Hydroalcoholic solvent system was found effective for extraction of both polar and semipolar phytoconstituents including flavonoids, glycosides, tannins, terpenoids, and phenolic compounds.

The prepared polyherbal blend showed good homogeneity and uniform mixing characteristics. No phase separation or incompatibility between herbal extracts was observed. Proper blending of herbal extracts is important because uniform

distribution of phytoconstituents ensures consistent therapeutic effect throughout the formulation.

Table 5: Characteristics of Polyherbal Extract Blend

Parameter	Observation
Color	Dark brown
Odor	Characteristic herbal odor
Consistency	Semisolid
Mixing property	Uniform
Stability	Stable
Solubility	Good in aqueous medium

The polyherbal blend remained stable during refrigerated storage conditions without significant changes in appearance or odor. Stability of herbal extract blend indicates compatibility of selected medicinal plants within the formulation.

Evaluation of Herbal-Probiotic Syrup Formulations

Five formulation batches designated as F1, F2, F3, F4, and F5 were prepared using different concentrations of polyherbal extracts while maintaining constant probiotic concentration. The prepared formulations were evaluated for organoleptic and physicochemical properties.

The syrup formulations showed uniform appearance and acceptable consistency. The presence of glycerin and syrup base improved mouth feel and stability of the formulations. No precipitation or phase separation was observed in most formulations during initial evaluation.

Table 6: Organoleptic Evaluation of Syrup Formulations

Formulation	Color	Odor	Taste	Appearance
F1	Light brown	Pleasant	Sweet	Uniform
F2	Brown	Aromatic	Sweet	Uniform
F3	Dark brown	Characteristic	Sweet	Uniform
F4	Brownish	Herbal	Slightly bitter	Uniform
F5	Dark brown	Strong herbal	Bitter-sweet	Uniform

Among all formulations, F3 exhibited better organoleptic acceptability due to balanced herbal concentration and pleasant taste profile. F5 showed slightly bitter taste because of higher concentration of herbal extracts, especially Curcuma longa and Aloe vera.

Physicochemical Evaluation

The prepared syrup formulations were evaluated for pH, viscosity, specific gravity, and sedimentation behavior. These parameters are important for determining formulation stability, patient acceptability, and suitability for oral administration.

The pH of all formulations remained within acceptable range suitable for oral syrup preparations and probiotic survival. Slightly acidic to neutral pH conditions help maintain stability of probiotics and prevent microbial contamination.

Table 7: Physicochemical Evaluation of Syrup Formulations

Parameter	F1	F2	F3	F4	F5
pH	5.8	5.9	6.1	6.0	6.2
Viscosity	Moderate	Moderate	Good	Good	High
Specific gravity	1.18	1.20	1.22	1.23	1.25
Sedimentation	Absent	Absent	Absent	Slight	Slight

The viscosity of formulations increased gradually with increase in concentration of herbal extracts. Higher viscosity observed in F5 may be due to increased concentration of plant mucilage and dissolved phytoconstituents. Moderate viscosity observed in F3 was considered ideal because it improved mouth feel while maintaining easy pourability.

Specific gravity values of all formulations were within acceptable range indicating uniform syrup consistency. Slight sedimentation observed in F4 and F5 may be associated with higher concentration of insoluble phytoconstituents present in the formulation.

Probiotic Viability Study

The viability of probiotic organisms is one of the most important parameters in development of herbal-probiotic formulations. The formulations were evaluated for survival of *Lactobacillus acidophilus* and *Bifidobacterium bifidum* during preparation and storage.

The probiotic cultures remained viable in all formulations indicating compatibility between herbal extracts and probiotic organisms. Refrigerated storage conditions and controlled formulation temperature helped preserve microbial viability.

Table 8: Probiotic Viability Study

Formulation	Viability Observation
F1	Good
F2	Good
F3	Excellent
F4	Satisfactory
F5	Moderate

Among all formulations, F3 exhibited highest probiotic viability. The balanced concentration of herbal extracts and suitable pH conditions in F3 may have contributed to better survival of probiotics. Slight reduction in viability observed in F5 may be associated with higher concentration of phytoconstituents possessing mild antimicrobial effects.

The viability results indicate that probiotics can survive successfully within herbal syrup formulation when proper processing and storage conditions are maintained.

Antioxidant Activity

The antioxidant activity of herbal-probiotic syrup formulations was evaluated using DPPH free radical scavenging assay. Oxidative stress plays an important role in development of intestinal inflammation and mucosal damage associated with IBS and IBD. Therefore, antioxidant activity is

considered important for gastrointestinal protective formulations.

All formulations exhibited concentration-dependent antioxidant activity due to presence of flavonoids, phenolic compounds, curcuminoids, terpenoids, and probiotic metabolites.

Table 9: Antioxidant Activity of Syrup Formulations

Formulation	Antioxidant Activity
F1	Moderate
F2	Good
F3	Excellent
F4	Good
F5	Moderate

The strong antioxidant activity observed in F3 may be due to synergistic effect of *Curcuma longa*, *Aloe vera*, Ginger extract, and probiotic metabolites. Curcuminoids present in turmeric and phenolic compounds present in herbal extracts contribute significantly to free radical scavenging activity.

Antioxidant activity of the formulation may help reduce oxidative stress-mediated intestinal damage and improve mucosal healing in IBS and IBD conditions.

Anti-inflammatory Activity

The anti-inflammatory activity of the formulations was evaluated using protein denaturation inhibition method. Inflammatory reactions are associated with denaturation of proteins and release of inflammatory mediators.

The herbal-probiotic formulations showed significant anti-inflammatory activity due to presence of flavonoids, phenolic compounds, curcuminoids, glycyrrhizin, and probiotic metabolites.

Table 10: Anti-inflammatory Activity of Syrup Formulations

Formulation	Anti-inflammatory Activity
F1	Moderate
F2	Good
F3	Excellent
F4	Good
F5	Moderate

The anti-inflammatory effect observed in F3 was comparatively higher than other formulations. This may be due to optimal concentration of anti-inflammatory phytoconstituents such as curcumin, glycyrrhizin, gingerols, and menthol compounds.

The anti-inflammatory activity of the formulation may help reduce intestinal irritation, abdominal pain, and mucosal inflammation associated with IBS and IBD.

Gut Microbiota Modulation Potential

The prepared herbal-probiotic formulation demonstrated promising gut microbiota modulation potential due to presence of beneficial probiotic strains and herbal phytoconstituents. Probiotic organisms help restore balance of intestinal microbiota by inhibiting pathogenic bacteria and promoting growth of beneficial microorganisms.

The herbal extracts may further support gut microbiota by reducing intestinal inflammation, improving mucosal barrier function, and providing favorable intestinal environment for probiotic colonization. The synbiotic combination of herbs and probiotics therefore provides multidimensional therapeutic effect for gastrointestinal disorders.

Stability Study

The prepared syrup formulations were subjected to short-term stability studies under refrigerated and room temperature conditions. During stability evaluation, the formulations were examined periodically for color, odor, pH, sedimentation, probiotic viability, and overall appearance.

The formulations remained stable throughout the study period without major changes in physicochemical characteristics. F3 showed comparatively better stability profile and maintained probiotic viability more effectively than other batches.

Table 11: Stability Study Observations

Parameter	Observation
Color stability	Maintained
Odor stability	Stable
pH stability	Acceptable
Sedimentation	Minimal
Probiotic viability	Preserved
Overall appearance	Stable

The stability findings confirmed suitability of syrup dosage form for incorporation of herbal extracts and probiotics. Refrigerated storage conditions were found beneficial for maintaining probiotic viability and formulation stability.

The present investigation demonstrated that herbal-probiotic syrup formulation can be prepared successfully using medicinal plant extracts and probiotic cultures. The prepared formulations showed satisfactory physicochemical properties, probiotic viability, antioxidant activity, anti-inflammatory activity, and stability characteristics.

Among all formulations, F3 exhibited better overall performance due to balanced concentration of herbal extracts and probiotics. The formulation provided acceptable organoleptic properties, stable physicochemical characteristics, excellent probiotic survival, and superior biological activities.

The synergistic combination of medicinal herbs and probiotics may provide effective therapeutic approach for management of IBS and IBD through restoration of gut microbiota, reduction of oxidative stress, improvement of intestinal barrier function, and suppression of inflammatory processes.

The findings of the study indicate that herbal-probiotic syrup formulations may serve as promising natural alternatives for gastrointestinal disorders associated with gut microbial imbalance and intestinal inflammation.

Future Scope

Further studies can be performed to evaluate the clinical effectiveness of the herbal-probiotic syrup formulation in patients suffering from IBS and IBD. Detailed in-vivo pharmacological studies and toxicity evaluations may help establish safety and therapeutic efficacy of the formulation. Long-term stability studies can also be carried out to improve shelf life and probiotic survival during storage.

Advanced microbiological and molecular studies may help understand the mechanism of gut microbiota modulation produced by the herbal-probiotic combination. The formulation may also be modified into sugar-free, pediatric, and ready-to-use probiotic preparations for wider therapeutic applications. Advanced analytical techniques such as HPLC, GC-MS, FTIR, and microbiome sequencing studies can further be used for detailed characterization of phytoconstituents, probiotic interactions, and formulation standardization.

Summary

The present study was carried out to develop and evaluate a herbal-probiotic syrup formulation for gut microbiota modulation in IBS and IBD. Medicinal plants such as Aloe vera, Curcuma longa, Mentha piperita, Zingiber officinale, and Glycyrrhiza glabra were selected because of their anti-inflammatory, antioxidant, and gastroprotective properties. Hydroalcoholic extracts of these herbs were prepared and combined with probiotic strains including Lactobacillus acidophilus and Bifidobacterium bifidum to formulate herbal-probiotic syrup batches.

The prepared formulations were evaluated for organoleptic properties, physicochemical parameters, probiotic viability, antioxidant activity, anti-inflammatory activity, and stability. The results showed satisfactory formulation characteristics and good probiotic survival. Among all formulations, F3 exhibited better antioxidant and anti-inflammatory activities along with acceptable stability and organoleptic properties. The findings suggest that the herbal-probiotic syrup formulation may be useful for restoration of gut microbiota and

management of gastrointestinal disorders associated with IBS and IBD.

CONCLUSION:

The present investigation demonstrated successful development of a herbal-probiotic syrup formulation intended for gut microbiota modulation in IBS and IBD. The formulation combined medicinal herbs and probiotics to provide synergistic therapeutic benefits for gastrointestinal health. The prepared syrup formulations showed satisfactory physicochemical properties, acceptable stability, and good probiotic viability during storage conditions.

The antioxidant and anti-inflammatory studies confirmed beneficial biological activities of the herbal-probiotic formulation. The selected medicinal herbs and probiotics may help reduce intestinal inflammation, oxidative stress, and microbial imbalance associated with IBS and IBD. Among all prepared formulations, F3 showed better overall performance due to balanced composition of herbal extracts and probiotic cultures.

The study indicates that herbal-probiotic syrup formulations may serve as promising natural therapeutic alternatives for gastrointestinal disorders with improved patient acceptability and reduced side effects compared to conventional treatment approaches.

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