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Development of smoothie and its effect on constipation, consistency of stool and bloating among population residing in Jalgaon city

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Abstract

This study presents an in-depth exploration of the multifaceted challenges associated with chronic constipation, focusing on the consistency of stool and bloating. It underscores the imperative for personalized, multidimensional approaches that consider physiological, psychological, and social factors. The role of dysbiosis in gut microbiota is highlighted as a significant factor in constipation, advocating for innovative strategies like prebiotics to restore microbial balance.

The study introduces natural remedies in the form of smoothies, carefully crafted from locally sourced ingredients, with specific emphasis on the Coriander and Palak variants. These smoothies emerge as promising interventions, promoting gastrointestinal health. Rigorous sensory evaluations, employing both Composite Rating Score and Hedonic score analyses, provide comprehensive insights into the organoleptic attributes of these smoothies.

Analyzing the data using ANOVA, the study delves into the clinical efficacy of the smoothie intervention over a one-month period. The findings reveal substantial improvements in various gastrointestinal symptoms, highlighting the positive impact on digestive well-being. Despite these promising outcomes, the study acknowledges specific limitations, particularly in addressing bloating during menstrual periods in females, suggesting avenues for targeted modifications in future interventions.

Organoleptic evaluations further enrich the study, with the Coriander and Palak smoothies standing out as preferred choices based on both Composite Rating Score and Hedonic score assessments. These outcomes underscore the significance of sensory attributes in the success of dietary interventions.

In conclusion, this study not only offers effective solutions for chronic constipation but envisions a future where healthful eating becomes a culturally embedded, joyful experience. The integration of both clinical and sensory evaluations provides a comprehensive understanding, paving the way for more tailored and appealing dietary recommendations in the management of gastrointestinal disorders.

Keywords: Chronic constipation, dysbiosis, smoothies, sensory evaluations, gastrointestinal disorders, bloating, gut microbiotic, fibre, constipation

Introduction

Chronic constipation, a prevalent functional gastrointestinal disorder, has far-reaching effects on the global population, posing substantial challenges to both individuals' well-being and healthcare resources [Suares & Ford, 2011] ^[14]. Beyond physical discomfort, it delves into intricate psychological and social dimensions, significantly complicating the clinical landscape [Naseer & Poola, 2020] ^[9]. Physically, it disrupts daily activities, leading to fatigue, irritability, and discomfort, exacerbating the psychological burden. Anxiety, stress, and reduced self-confidence become prevalent, reflecting the condition's persistent nature. Socially, its unpredictable symptoms lead to social isolation, straining personal and professional relationships. In healthcare, chronic constipation's diverse nature complicates diagnosis and treatment, necessitating a personalized, multifaceted approach addressing physiological, psychological, and social factors. Scientifically, the gut microbiota's balance plays a vital role, with disruptions associated with gastrointestinal disorders, including chronic constipation, highlighting the importance of understanding this intricate relationship for overall health [Peredo-Lovillo & Romero-Luna, 2020] ^[11].

The gut microbiota plays a crucial role by fermenting indigestible carbohydrates, producing metabolites like short-chain fatty acids (SCFAs) and organic acids, which serve as signaling molecules affecting local and systemic processes including metabolism, immune response, and neurobehavioral functions [Peredo-Lovillo & Romero-Luna, 2020] ^[11].

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These microbial byproducts directly impact bowel habits within the gastrointestinal system, modulating motility, secretion, and absorption. In the context of chronic constipation, characterized by difficult and infrequent bowel movements, disruptions in the gut microbiota's composition can hinder essential metabolite production and signaling, potentially contributing to constipation onset or worsening. Additionally, the bidirectional communication between the gut and the central nervous system, mediated by these metabolites, highlights the significant impact of psychological factors such as stress and anxiety on gut motility and digestive well-being, influencing constipation severity. Understanding these interactions not only enhances our understanding of chronic constipation but also opens doors to innovative therapeutic approaches. Modulating the gut microbiota through interventions like personalized diets, probiotics, or prebiotics holds promise in restoring microbial balance and alleviating constipation-related symptoms comprehensively. In contemporary gastrointestinal research, the focus has notably shifted to prebiotics, marking a paradigm shift in managing chronic constipation [Naseer & Poola, 2020] ^[9]. Unlike probiotics, prebiotics selectively nourish beneficial gut bacteria, supporting their growth and metabolic activity, thereby profoundly influencing gut health [Gibson & Roberfroid, 1995] ^[5].

Prebiotics, a category of dietary compounds resistant to digestion in the upper gastrointestinal tract, have gained significant attention due to their potential benefits for gastrointestinal health [Sarbin & Shahrul, 2011] ^[12]. Compounds like lactulose, lactitol, and lactosucrose, among others, have demonstrated their efficacy as prebiotics by reaching the colon intact, where they are fermented by beneficial gut bacteria such as *Bifidobacterium* and *Lactobacillus*. Lactulose, despite potential side effects, promotes a healthier gut microbiota composition through fermentation, producing beneficial metabolites. Similarly, lactose-derived prebiotics like lactitol and lactosucrose, resistant to upper gastrointestinal digestion, stimulate specific beneficial bacteria, fostering a balanced gut microbiota. Moreover, recent research suggests that combining lactose-derived prebiotics with probiotics can enhance therapeutic effects, creating a promising approach to optimize gastrointestinal health and overall well-being [Sarbin & Shahrul, 2011] ^[12].

Chronic constipation, a widespread gastrointestinal disorder characterized by infrequent bowel movements, hard stools, and uncomfortable straining, significantly diminishes the quality of life for a substantial portion of the population [Suarez & Ford, 2011] ^[14]. Understanding its multifaceted nature involves delving into the intricate interplay of physiological, psychological, and lifestyle factors, demanding a comprehensive approach to management [Bharucha & Wald, 2019] ^[3]. Recent scientific investigations have shed light on the pivotal role of the gut microbiota in both the development and persistence of constipation, emphasizing the concept of dysbiosis, an imbalance in gut bacteria composition [Zhang & Wang, 2021] ^[18]. Specific strains, notably *Bifidobacterium*, within this microbial community, have garnered attention due to their influence on critical factors such as gut motility, transit time, and stool consistency, all central to the pathophysiology of constipation [Zhang & Wang, 2021] ^[18]. Prebiotics, dietary fibers that selectively stimulate the growth and activity of beneficial gut

bacteria like *Bifidobacterium* and *Lactobacilli*, emerge as promising therapeutic agents in constipation management [Gibson & Roberfroid, 1995] ^[5]. By fostering the proliferation of these specific microbial populations, prebiotics restore a balanced gut microbiota composition, alleviating the symptoms of constipation. Furthermore, the fermentation of prebiotics by these beneficial gut bacteria results in the production of short-chain fatty acids (SCFAs), which play a key role in improving gut motility and overall gastrointestinal health, underscoring the potential of prebiotics as a natural and holistic approach to managing constipation effectively [Holscher, 2017] ^[6]. This comprehensive understanding highlights the intricate mechanisms through which prebiotics offer a detailed and targeted solution for individuals struggling with chronic constipation.

Bloating, a common gastrointestinal complaint characterized by abdominal fullness and discomfort, is now being understood through intricate mechanisms involving gut microbiota dysbiosis and specific substrate fermentation [Zhang & Jiang, 2020] ^[17]. Dysbiosis, the imbalance in gut microbial communities, leads to excessive hydrogen and methane gas production, contributing significantly to abdominal distension and discomfort [Zhang & Jiang, 2020] ^[17]. Recent research emphasizes the potential of prebiotics, indigestible dietary compounds, in addressing bloating concerns. Prebiotics play a multifaceted role by selectively promoting the growth of beneficial bacterial strains such as *Bifidobacterium* and *Lactobacilli* [Sarbin & Shahrul, 2011] ^[12] [Zhang & Jiang, 2020] ^[17]. These bacteria help establish a balanced gut microbiota composition, outcompeting gas-producing microbes and reducing overall gas production and bloating. Furthermore, prebiotics enhance the efficiency of carbohydrate fermentation by providing readily available energy sources for beneficial microbes, thereby minimizing the accumulation of undigested substrates responsible for bloating [Zhang & Jiang, 2020] ^[17]. Additionally, prebiotic fermentation yields short-chain fatty acids (SCFAs), especially butyrate, which play a pivotal role in influencing gut physiology and motility, potentially ameliorating bloating symptoms [Peredo-Lovillo & Romero-Luna, 2020] ^[11] [Zhang & Jiang, 2020] ^[17]. While ongoing clinical trials continue to explore these effects, prebiotics represent a promising avenue, offering a detailed and tailored approach to alleviate bloating and enhance overall gastrointestinal well-being.

Bowel movements, a fundamental aspect of gastrointestinal health, are intricate processes involving coordinated actions of the gastrointestinal tract and muscles. The regularity and consistency of bowel movements serve as indicators of a healthy digestive system. Infrequent or difficult-to-pass stools often signal constipation, a prevalent gastrointestinal issue causing discomfort. Recent research delves into the potential of prebiotics to enhance bowel movement regularity, addressing these concerns comprehensively. Prebiotics, non-digestible dietary compounds, play a pivotal role by selectively promoting the growth of beneficial bacteria, particularly *Bifidobacterium* and *Lactobacilli*, thus fostering a balanced gut microbiota composition. This modulation contributes to optimal gut function, potentially preventing constipation. Moreover, prebiotic fermentation results in the production of short-chain fatty acids (SCFAs), notably butyrate, known for improving gut motility and regularity. These SCFAs positively influence gut physiology, promoting more comfortable and regular bowel movements. Prebiotics

also influence stool consistency, facilitating the formation of soft and well-formed stools, easing bowel movements and reducing discomfort associated with constipation. While ongoing clinical trials, continue to explore prebiotics' specific impacts on bowel movements, these mechanisms underscore the potential of prebiotics as a natural and detailed approach to support gastrointestinal health and alleviate constipation-related issues comprehensively [Peredo-Lovillo & Romero-Luna, 2020]^[11] [Sarbin & Shahul, 2011]^[12] [Schoemaker & Hageman, 2019]^[13].

In the pursuit of natural remedies for gastrointestinal health, the fusion of carefully selected dietary elements has emerged as an intriguing frontier. Smoothies, in particular, have gained significant attention, especially when crafted from a thoughtfully curated blend of green leafy vegetables, dates, and bananas. This combination represents a potent concoction designed to address the complex issues associated with chronic constipation. Green leafy vegetables form the foundation of this powerful elixir, known for their nutritional richness and abundant dietary fibers, both soluble and insoluble, which contribute to regular bowel movements and the softening of stool consistency. They also provide essential nutrients such as vitamins A, C, K, and minerals like iron and calcium, promoting overall well-being. Dates, celebrated for their antioxidant properties due to a high phenolic content, combat oxidative stress linked to gastrointestinal disorders, including constipation. Additionally, dates offer natural sugars and fibers, acting as a gentle laxative. Bananas, rich in prebiotic fibers (inulin) and essential electrolytes like potassium, support gut health, enhance gut motility, and maintain proper muscle function. When blended into a smoothie, these ingredients synergize, providing bulk, softness, antioxidants, natural sugars, and prebiotics to support regular, comfortable bowel movements. This holistic approach, which transforms these elements into a delicious and easily consumable form, offers a promising solution for individuals seeking natural remedies for chronic constipation, aligning with the holistic approach to health advocated by contemporary medicine. [Al-Shwyeh, 2019]^[1] [Pateiro & Domínguez, 2023]^[10] [Aslam & Tahreem, 2020]^[2] [van der Schoot & Drysdale, 2022]^[16].

Materials and Methods

In this investigation, 45 male and female participants, ranging in age from 16 to 45 years and residing in the Jalgaon region of Maharashtra, were thoughtfully selected between October and November 2023. Before the formative study phase commenced, all subjects provided comprehensive informed written consent. To assess the prevalence of gut disorders, a pre-questionnaire was administered, followed by the diagnosis of the disorder's severity. Based on preliminary results and participant willingness, an experimental sample of 35 patients was recruited for the trial. The experimental intervention involved the development of a targeted smoothie to effectively address gastrointestinal concerns for the enrolled participants. Throughout the trial, participants were instructed to maintain their regular diets and physical activity routines, reporting any discomfort promptly. Weekly follow-up sessions were conducted to monitor adherence and assess potential side effects. Systematic data collection included participant compliance, dietary intake, physical activity, and reported side effects, forming the foundation for ongoing trial analysis. The study strictly adhered to ethical standards and

data confidentiality protocols to ensure research integrity and validity.

The formulation of smoothies involved a thorough exploration of commonly consumed green leafy vegetables within households, focusing on options universally suitable for individuals. Specifically, coriander, spinach, and mint leaves, along with bananas, were sourced from reputable local vegetable vendors in the urban area of Vadodara. Additionally, lettuce and dates were procured from D-mart stores to ensure the high quality and freshness of the products. Upon arrival, rigorous quality checks were conducted to ensure the freshness and integrity of the ingredients. The vegetables underwent proper washing and careful drying to eliminate any contaminants, with precise weight assessments carried out to measure the ingredients required for the smoothies' preparation. From these high-quality ingredients, three distinct smoothie variations were formulated. Throughout these variations, mint leaves, bananas, dates, and water remained constant, serving as foundational elements, while the primary ingredient differed. The smoothies were crafted using palak (spinach), lettuce, and coriander as the main components, each contributing unique nutritional properties. The emphasis throughout this process was on sourcing fresh, locally available ingredients, ensuring the final smoothie formulations would be of the highest quality and nutritional value.

At the conclusion of the one-month intervention, a thorough examination of the observed outcomes was conducted. The data collected during this period was then meticulously compared with the baseline responses obtained from the participants before the commencement of the trial. This comparative analysis was designed to quantify and evaluate the effectiveness of the smoothie intervention in positively impacting the gastrointestinal health of the participants.

Standardisation of smoothies

The standardisation process of the smoothie formulations involved a series of meticulous trials and measurements to achieve the desired taste, color, and texture for each variant. This rigorous procedure ensured the uniformity and quality of the final products.

- a. **Palak smoothie (Spinach):** For the Palak smoothie, 42 grams of palak (spinach) were carefully blended with 21 grams of mint leaves, 230 grams of banana, and 57 grams of dates. To attain the desired consistency, 125 ml of water was added. The ingredients were blended properly until the optimal consistency was achieved, ensuring a harmonious blend of flavors and textures.
- b. **Lettuce smoothie:** In the Lettuce smoothie variant, 51 grams of lettuce were combined with 22 grams of mint leaves, 250 grams of banana, and 54 grams of dates. To achieve the desired consistency, 160 ml of water was added. The blending process was conducted until the ingredients seamlessly merged into a homogeneous mixture, guaranteeing a delightful drinking experience.
- c. **Coriander smoothie:** For the Coriander smoothie, 17 grams of coriander were blended with 9 grams of mint leaves, 150 grams of banana, and 42 grams of dates. To reach the optimum consistency, 145 ml of water was incorporated. The ingredients were blended thoroughly, ensuring the Coriander smoothie attained the desired texture and taste profile.

Sensory evaluation

In the sensory evaluation of the developed smoothie recipes, a carefully curated panel of 30 individuals was formed, comprising both semi-trained experts and untrained panellists. The semi-trained segment consisted of esteemed individuals including professors and doctoral students from the Department of Foods and Nutrition, possessing extensive expertise in sensory food evaluation. Alongside them, untrained panellists, young students aged between 18-25 years, were included to represent the fresh perspectives of the target consumer demographic. This diverse panel aimed to comprehensively assess the consumer acceptability of the developed food products, ensuring a broad range of perspectives.

The panelists, equipped with discerning palates, meticulously evaluated the dimensions of individual quality characteristics, namely taste, color, flavor, texture, and overall acceptability, employing both the Composite Rating Score methodology, pioneered by Joshi in 2006, and the hedonic scale [Joshi, 2006] ^[15]. The Composite Rating Score methodology involved evaluating different variants based on specific organoleptic attributes, with each parameter allocated a maximum score of 20, leading to a total possible score of 100 for each variant. Simultaneously, the hedonic scale, a widely recognized tool in sensory evaluation, allowed panelists to express their preference levels, ranging from 'dislike extremely' to 'like extremely' [Swaminathan, 1995] ^[8].

During the evaluation process, panelists were tasked with assigning individual scores and hedonic ratings to the variants under consideration. This detailed scoring system facilitated

nuanced evaluations, enabling the differentiation of subtle sensory nuances among the variants. Following the evaluations, the individual scores and hedonic ratings assigned by the panelists were meticulously compiled and analyzed comprehensively. This rigorous analysis allowed for the identification of patterns, preferences, and areas of improvement within the variants, providing a deep understanding of the sensory profile of the developed food products. The integration of objective scoring criteria and subjective preferences from the hedonic scale facilitated a systematic interpretation of the sensory data, enabling informed conclusions and recommendations based on the panelists' assessments.

Proximate analysis

Based on the recommendations and results of the sensory evaluation, the coriander and palak smoothies were finalized. The nutrient analysis of the coriander and palak smoothies was conducted in an NABL Accredited laboratory. The nutritional values, including total fat, protein, carbohydrates, energy, added sugar, crude fiber, calcium, iron, zinc, sodium, and potassium, were determined for both smoothies after the sensory evaluation process. These values were obtained using the test methods specified in the FSSAI MANUAL for total fat, protein, added sugar, crude fiber, calcium, iron, zinc, sodium, and potassium. Additionally, the carbohydrate content was determined using the test method outlined in IS 1656 (Annexure C): 2022 ^[17], while energy content was assessed following the procedure from SATRL/SOP/02B/II ISSUE No.1:2013.

Table 1: Nutritional values of Spinach and coriander smoothie

| Spinach Smoothie | | | | |
|--------------------|---------------|--------|-----------|----------------------------------|
| Sr. No. | Parameters | Result | Units | Test Method |
| 1 | Total Fat | 0.93 | g/100g | FSSAI Manual |
| 2 | Protein | 0.85 | g/100g | FSSAI Manual |
| 3 | Carbohydrates | 18.95 | g/100g | IS 1656 (Annexure C): 2022 |
| 4 | Energy | 87.57 | Kcal/100g | SATRL/SOP/02B/II ISSUE No.1:2013 |
| 5 | Added Sugar | 0.00 | g/100g | FSSAI Manual |
| 6 | Crude Fibre | 7.92 | g/100g | FSSAI Manual |
| 7 | Calcium | 102.97 | mg/100g | FSSAI Manual |
| 8 | Iron | 1.50 | mg/100g | FSSAI Manual |
| 9 | Zinc | 0.31 | mg/100g | FSSAI Manual |
| 10 | Sodium | 197.09 | mg/100g | FSSAI Manual |
| 11 | Potassium | 168.05 | mg/100g | FSSAI Manual |
| Coriander Smoothie | | | | |
| Sr. No. | Parameters | Result | Units | Test Method |
| 1 | Total Fat | 0.48 | g/100g | FSSAI Manual |
| 2 | Protein | 1.27 | g/100g | FSSAI Manual |
| 3 | Carbohydrates | 16.53 | g/100g | IS 1656 (Annexure C): 2022 |
| 4 | Energy | 75.52 | Kcal/100g | SATRL/SOP/02B/II ISSUE No.1:2013 |
| 5 | Added Sugar | 0.00 | g/100g | FSSAI Manual |
| 6 | Crude Fibre | 12.44 | g/100g | FSSAI Manual |
| 7 | Calcium | 138.44 | mg/100g | FSSAI Manual |
| 8 | Iron | 2.28 | mg/100g | FSSAI Manual |
| 9 | Zinc | 0.36 | mg/100g | FSSAI Manual |
| 10 | Sodium | 134.72 | mg/100g | FSSAI Manual |
| 11 | Potassium | 65.24 | mg/100g | FSSAI Manual |

Results and Discussion

Organoleptic evaluation of smoothies based on composite rating score using ANOVA analysis

The organoleptic evaluation employed the Composite Rating Score and underwent ANOVA analysis to offer

comprehensive insights into the sensory attributes of three distinct smoothie variants: palak, lettuce, and coriander. The palak smoothie showcased commendable sensory characteristics, with mean scores of 17.86 ± 2.34 for color, 17.7 ± 2.27 for flavor, 17.76 ± 2.96 for taste, 18.26 ± 2.04 for

texture, and 18.4 ± 2.16 for overall acceptability, resulting in a total score of 90 ± 9.7 , indicating a well-rounded and highly acceptable sensory profile. Conversely, the lettuce variant demonstrated slightly lower mean scores across parameters, resulting in a total score of 83.76 ± 10.31 , suggesting a good but comparatively less preferable sensory experience. The coriander smoothie emerged as a strong contender with high mean scores across all attributes, reaffirming its exceptional sensory appeal with a total score of 90.4 ± 6.87 .

The ANOVA analysis revealed statistically significant differences among the smoothies, highlighting palak and coriander variants as preferred choices due to their superior

organoleptic qualities. The nuanced differences in color, flavor, taste, texture, and overall acceptability collectively contribute to the palatability and acceptance of these smoothies, crucial factors in their potential as dietary supplements. This meticulous evaluation of individual parameters provides valuable data for the broader discourse on formulating effective and appealing interventions for promoting gastrointestinal well-being. The preference for palak and coriander smoothies, supported by their robust sensory profiles, represents a significant outcome derived from rigorous sensory evaluation and statistical analysis.

Table 2: Mean composite score of smoothies using ANOVA analysis

| Variant | Colour (20) | Flavour (20) | Taste (20) | Texture (20) | Overall Acceptability (20) | Total score (100) |
|-----------|------------------|------------------|------------------|------------------|----------------------------|-------------------|
| Palak | 17.86 ± 2.34 | 17.7 ± 2.27 | 17.76 ± 2.96 | 18.26 ± 2.04 | 18.4 ± 2.16 | 90 ± 9.7 |
| Lettuce | 16.63 ± 3.08 | 16.53 ± 2.75 | 16.4 ± 2.82 | 17 ± 1.98 | 17.2 ± 2.00 | 83.76 ± 10.31 |
| Coriander | 18.2 ± 1.75 | 17.56 ± 1.88 | 18.26 ± 1.57 | 17.83 ± 1.74 | 18.53 ± 1.63 | 90.4 ± 6.87 |

Organoleptic evaluation of smoothies based on Hedonic score using ANOVA analysis

The hedonic evaluation, a crucial component of sensory analysis, employed a scale ranging from "like extremely" (score of 9) to "dislike extremely" (score of 1). The ANOVA analysis of hedonic scores provided insightful comparisons regarding the palatability and overall acceptability of three distinct smoothie variants: palak, lettuce, and coriander. The palak smoothie demonstrated commendable likability with a mean hedonic score of 7.96 ± 1.33 , indicating a strong preference among panelists and highlighting its potential as a palatable and well-received dietary intervention. In contrast, the lettuce smoothie exhibited a slightly lower mean hedonic score of 7.35 ± 1.26 , suggesting favorable reception but with a marginally lower overall palatability compared to the palak variant. The coriander smoothie emerged as a standout in palatability, boasting a notably higher mean hedonic score of 8.19 ± 0.7 , positioning it as a preferred choice among panelists.

ANOVA analysis revealed statistically significant differences in hedonic scores, establishing coriander and palak smoothies as top contenders. The higher hedonic scores indicated a greater degree of satisfaction and preference, crucial factors for the success of dietary interventions. The nuanced differences in hedonic scores provided valuable insights into sensory nuances contributing to overall likability, emphasizing the importance of the hedonic scale as a robust tool for evaluating the organoleptic qualities of these interventions. In conclusion, both palak and coriander smoothies emerged as highly palatable choices, with coriander securing a slightly higher likability score, underscoring the importance of considering sensory attributes alongside nutritional aspects in formulating effective dietary interventions for promoting gastrointestinal health.

Table 3: Mean Hedonic score of smoothies using ANOVA analysis

| Variant | Hedonic score (9) | |
|-----------|-------------------|------------|
| Palak | 7.96 | ± 1.33 |
| Lettuce | 7.35 | ± 1.26 |
| Coriander | 8.19 | ± 0.7 |

Impact on gastrointestinal disorders post intervention

The detailed examination of pre and post-intervention data on gastrointestinal symptoms provides valuable insights into the

efficacy of the prescribed smoothie in addressing a spectrum of digestive issues over a one-month intervention. The diverse range of symptoms evaluated, along with the corresponding percentage changes, illuminates the nuanced impact of the smoothie on participants' gastrointestinal well-being.

- 1. Irregularly Passing Stool:** The substantial decrease in irregular stool patterns, from 94.28% to 20%, underscores the profound effectiveness of the smoothie in promoting regular bowel movements. The impressive effectiveness rate of 78.78% suggests a significant positive shift in participants' digestive regularity.
- 2. No Fixed Time:** The reduction in individuals reporting no fixed time for bowel movements, from 48.57% to 11.4%, highlights the smoothie's role in establishing a more structured and regular pattern. The high effectiveness rate of 76.47% accentuates the intervention's success in mitigating irregularity.
- 3. More Than Once a Day:** The notable decrease in the frequency of multiple bowel movements per day, from 40% to 14.28%, reflects the smoothie's impact on regulating bowel habits. With a substantial effectiveness rate of 64.28%, the intervention demonstrates its efficacy in addressing hyperactive bowel patterns.
- 4. Difficulty Passing Stool:** Participants experiencing difficulty in passing stool witnessed a considerable improvement, with the percentage dropping from 74.28% to 22.8%. This suggests that the smoothie intervention significantly contributes to smoother and more comfortable bowel movements, resulting in an effectiveness rate of 69.23%.
- 5. Facing Gas Problems:** The reduction in participants reporting gas-related issues, from 54.28% to 14.28%, indicates the positive influence of the smoothie on reducing gastrointestinal discomfort. The notable effectiveness rate of 73.68% emphasizes the intervention's impact on minimizing gas-related problems.
- 6. Facing Bloating:** A substantial reduction in bloating instances, from 37.14% to 11.42%, signifies the smoothie's efficacy in alleviating this common digestive concern. With an effectiveness rate of 69.23%, the intervention demonstrates its capacity to reduce bloating and enhance digestive comfort.
- 7. Bloating During Periods (Females):** The reduction in

bloating during menstrual periods among females, from 22.85% to 17.14%, indicates a modest improvement. While the effectiveness rate is comparatively lower at 25%, it still suggests a positive impact on this specific aspect of female digestive health.

Table 4: Pre and post intervention comparison n (%)

| Gastrointestinal Syntoms | Pre - Smoothie | Post - Smoothie | % Effectiveness |
|------------------------------------|----------------|-----------------|-----------------|
| Irregularly passing stool | 33 (94.28) | 7 (20) | 78.778 |
| No fixed time | 17 (48.57) | 4 (11.4) | 76.47 |
| More than once a day | 14 (40) | 5 (14.28) | 64.28 |
| Difficulty Passing Stool | 26 (74.28) | 8 (22.8) | 69.23 |
| Facing gas problems | 19 (54.28) | 5 (14.28) | 73.68 |
| Facing bloating | 13 (37.14) | 4 (11.42) | 69.23 |
| Bloating during periods* (females) | 8 (22.85) | 6 (17.14) | 25 |

The meticulous examination of gastrointestinal symptom evolution pre and post-intervention consistently indicates a positive impact of the prescribed smoothie. The high

effectiveness rates observed across diverse parameters validate the intervention's comprehensive benefits, promoting digestive regularity, alleviating discomfort, and enhancing overall gastrointestinal well-being. This robust dataset provides compelling evidence, endorsing the integration of dietary interventions, exemplified by the prescribed smoothie, as a valuable component in managing gastrointestinal disorders. However, despite promising outcomes, acknowledging limitations is crucial, particularly in addressing bloating during menstrual periods in females. Further refinement and targeted studies are needed to enhance the smoothie intervention's overall effectiveness. Future research could explore tailored modifications to the smoothie composition, considering specific factors influencing gastrointestinal symptoms, especially those associated with female reproductive health. Additionally, a more extensive and diversified participant pool, encompassing varying demographics and medical histories, could contribute to a more nuanced understanding of the smoothie's efficacy across different populations, enhancing adaptability and providing a comprehensive picture of its potential impact.

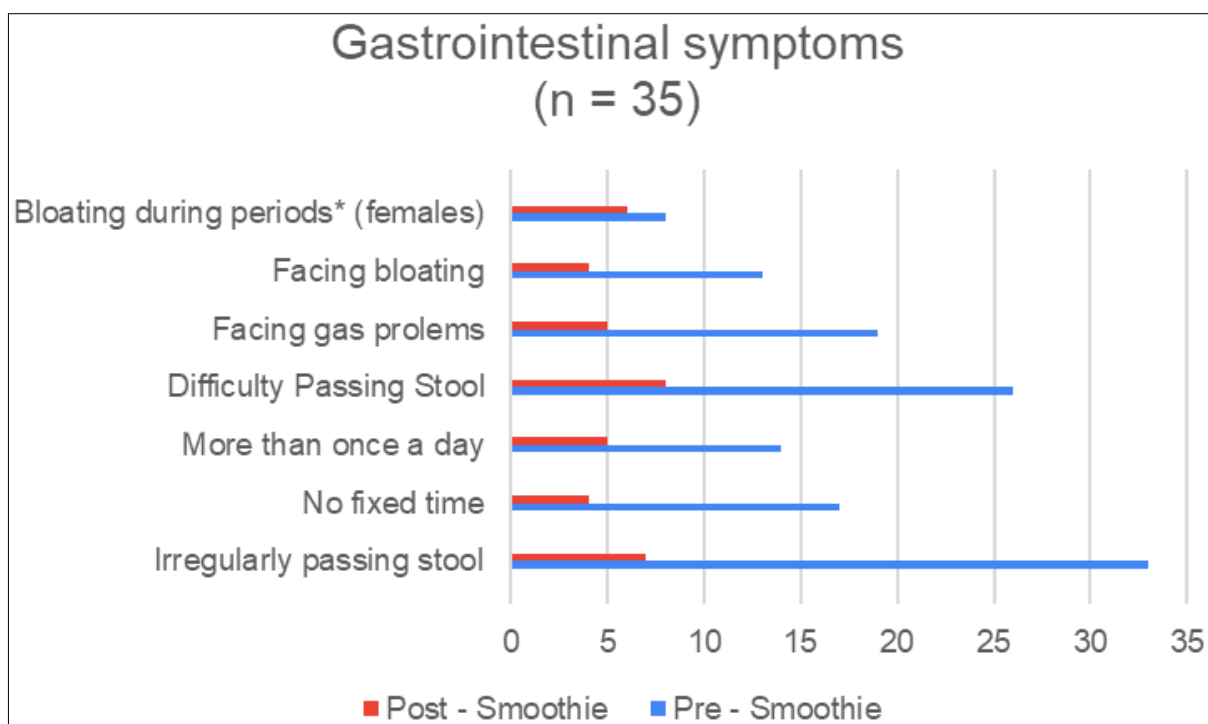


Fig 1: Pre and post intervention comparison chart

Conclusion

In the ever-evolving landscape of gastrointestinal health, this study ventures into a realm where scientific precision meets culinary artistry. Meticulously selecting and combining green leafy vegetables, dates, and bananas into innovative smoothies unveils a promising avenue for managing chronic constipation. The fusion of these elements, rooted in the rich nutritional profiles of green leafy vegetables, yields visually appealing and profoundly nourishing smoothies. Green leafy vegetables, revered for their fiber content and vital nutrients, serve as the backbone, promoting regular bowel movements and overall well-being. Dates, with their antioxidant prowess, not only add natural sweetness but also combat oxidative stress within the gastrointestinal system. Bananas, abundant in prebiotic fibers and essential electrolytes, actively contribute

to gut health, ensuring efficient digestion and comfortable bowel movements. Rigorous sensory evaluations confirm that these smoothies, notably the Coriander and Palak variants, meet the highest standards of taste while successfully merging nutrition with sensory satisfaction.

A fundamental aspect of this study lies in its emphasis on the integration of local resources. By utilizing ingredients readily available within specific communities, this approach enhances accessibility and incorporates cultural relevance. This alignment between dietary choices and community traditions fosters a deeper connection, bridging the gap between nutritional science and cultural practices. Such integration ensures the practicality and sustainability of these dietary interventions within diverse populations.

In conclusion, this study signifies the potential of innovative

dietary solutions in addressing the challenges of chronic constipation, creating a path for a future where healthful eating is a joyful, culturally rooted experience. Rooted in scientific rigor and gastronomic ingenuity, these insights mark a promising stride in the realm of gastrointestinal health, promising a healthier, more flavorful future for individuals seeking natural remedies for chronic constipation. The meticulous examination of each gastrointestinal symptom's evolution pre and post-intervention corroborates the positive impact of the prescribed smoothie. The high effectiveness rates observed across diverse parameters underscore the comprehensive benefits of the intervention, emphasizing its role in fostering digestive regularity, alleviating discomfort, and enhancing overall gastrointestinal well-being.

Despite these promising outcomes, it is imperative to acknowledge certain limitations and identified gaps within the intervention. While the smoothies demonstrate notable effectiveness, they do not exhibit complete efficacy against all symptoms, particularly in addressing bloating during menstrual periods in females. This specific scenario highlights the need for further refinement and targeted studies to enhance the overall effectiveness of the smoothie intervention. To address these identified gaps, future research endeavors could explore tailored modifications to the smoothie composition, considering specific factors influencing gastrointestinal symptoms, especially those associated with female reproductive health. Incorporating additional elements known to address bloating during menstrual periods could enhance efficacy. Moreover, a more extensive and diversified participant pool, including varying demographics and medical histories, could contribute to a nuanced understanding of the smoothie's efficacy across different populations, enhancing adaptability and providing a more comprehensive picture of its potential impact.

While the current data robustly supports the positive influence of the prescribed smoothie in gastrointestinal health, the identified gaps call for continued research and refinement. This iterative process is essential to tailor interventions more precisely, ensuring increased effectiveness and applicability across a broader spectrum of symptoms and populations. Through ongoing improvements and dedicated studies, dietary interventions like the prescribed smoothie can evolve into even more potent tools for managing gastrointestinal disorders.

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References

- Al-Shwyeh HA. Date Palm (*Phoenix dactylifera* L.) Fruit as Potential Antioxidant and Antimicrobial Agents. *J Pharm Bioallied Sci.* 2019 Jan-Mar;11(1):1-11. DOI: 10.4103/jpbs.JPBS_168_18. PMID: 30906133; PMCID: PMC6394164.
- Aslam T, Maqsood M, Jamshaid I, Ashraf K, Zaidi F, Khalid S, *et al.* Health Benefits and Therapeutic Importance of Green Leafy Vegetables (GLVs). *European Academic Research.* 2020;8(10):4213-4229.
- Bharucha AE, Wald A. Chronic Constipation. *Mayo Clin Proc.* 2019 Nov;94(11):2340-2357.
- DOI: 10.1016/j.mayocp.2019.01.031. PMID: 31054770; PMCID: PMC6829047.
- Gibson GR, Roberfroid MB. Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *J Nutr.* 1995;125(6):1401-1412.
- Holscher HD. Dietary fiber and prebiotics and the gastrointestinal microbiota. *Gut Microbes.* 2017 Mar 4;8(2):172-184. DOI: 10.1080/19490976.2017.1290756. PMID: 28165863; PMCID: PMC5390821.
- Indian Standards Institute. IS 1656 (Annexure C): 2022. MILK-Cereal Based Complementary Foods Specification (Fifth Revision of IS 1656).
- Swaminathan M. *Food Science and Experimental Foods.* Madras: Ganesh and Company; c1995. p. 293.
- Naseer M, Poola S, Uraz S, Tahan V. Therapeutic Effects of Prebiotics on Constipation: A Schematic Review. *Curr Clin Pharmacol.* 2020;15(3):207-215.
- Pateiro M, Domínguez R, Muneke PES, Nieto G, Bangar SP, Dhama K, *et al.* Bioactive Compounds from Leaf Vegetables as Preservatives. *Foods.* 2023 Feb 2;12(3):637. DOI: 10.3390/foods12030637. PMID: 36766166; PMCID: PMC9914076.
- Peredo-Lovillo A, Romero-Luna HE, Jiménez-Fernández M. Health promoting microbial metabolites produced by gut microbiota after prebiotics metabolism. *Food Res Int.* 2020 Oct;136:109473.
- Sarbini SR, Rastall RA. Prebiotics: Metabolism, Structure, and Function; c2011.
- Schoemaker MH, Hageman JHJ, Ten Haaf D, Hartog A, Scholtens PAMJ, Boekhorst J, *et al.* Prebiotic Galacto-Oligosaccharides Impact Stool Frequency and Fecal Microbiota in Self-Reported Constipated Adults: A Randomized Clinical Trial. *Nutrients.* 2022 Jan 12;14(2):309.
- Suares NC, Ford AC. Prevalence of, and risk factors for, chronic idiopathic constipation in the community: systematic review and meta-analysis. *Am J Gastroenterol.* 2011;106(9):1582-1591.
- Joshi VK. *Sensory Science.* Udaipur: Agrotech Publishing Academy; c2006. p. 266-268.
- Van der Schoot A, Drysdale C, Whelan K, Dimidi E. The Effect of Fiber Supplementation on Chronic Constipation in Adults: An Updated Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Am J Clin Nutr.* 2022 Oct 6;116(4):953-969. DOI: 10.1093/ajcn/nqac184. PMID: 35816465; PMCID: PMC9535527.
- Zhang C, Jiang J, Tian F, Zhao J, Zhang H, Zhai Q, *et al.* Meta-analysis of randomized controlled trials of the effects of probiotics on functional constipation in adults. *Clin Nutr.* 2020 Oct;39(10):2960-2969. DOI: 10.1016/j.clnu.2020.01.005. PMID: 32005532.
- Zhang S, Wang R, Li D, Zhao L, Zhu L. Role of gut microbiota in functional constipation. *Gastroenterology Rep (Oxf.).* 2021 Aug 6;9(5):392-401. DOI: 10.1093/gastro/goab035. PMID: 34733524; PMCID: PMC8560038.