JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

SWEET SCIENCE MEETS HERBAL THERAPY: DEVELOPMENT OF DATE SYRUP–BASED CHOCOLATE AS A NOVEL NUTRACEUTICAL DELIVERY SYSTEM FOR PAPAYA EXTRACT AND KALMEGH EXTRACT

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Abstract

The creation and assessment of a novel nutraceutical formulation utilizing a chocolate-based delivery method that incorporates extracts from Andrographis paniculata and Carica papaya is the main goal of this work. These herbal medications' strong bitterness, which restricts patient tolerance, is their main drawback. To get around this, date syrup, a natural sweetener, was used as a taste-masking agent to improve sensory qualities and offer functional value, while chocolate was used as a palatable transporter.

Nine formulations (F1–F9) were created by changing the sweetener and chocolate base composition while keeping the herbal extract concentration constant. The formulations were assessed for stability, physicochemical parameters, and organoleptic properties. Out of all the formulations, F6—which contains date syrup and dark compound chocolate performed the best, exhibiting acceptable sensory qualities, enhanced stability, and total flavour masking.

Good structural integrity and shelf stability were indicated by the improved formulation's acceptable physicochemical characteristics, which included the right pH, hardness, melting point, and low moisture content. The study underlines date syrup's function as a natural, nutritionally advantageous taste-masking agent and the efficacy of chocolate as a new drug delivery system (NDDS).

All things considered, the created herbal chocolate is a promising functional food and nutraceutical formulation that offers better palatability, increased patient compliance, and possible therapeutic advantages, particularly for younger and older populations.

KEYWORD Medicated Chocolate, Chocolate formulation, Papaya leaf powder, kalmegh powder, Paediatrics.

Introduction

1.Functional Foods Concept:

Foods that offer health advantages beyond basic nutrition because they include physiologically active substances including polyphenols, flavonoids, vitamins, and minerals are referred to as functional foods [1,2]. These foods play a significant role in promoting overall health and reducing the risk of chronic diseases such as cardiovascular disorders, diabetes, and cancer [3]. Growing awareness of preventative healthcare and the need for safer, natural substitutes for traditional medications are driving the growing interest in functional foods [4].

Because they can improve immunological responses, lower oxidative stress, and modify physiological processes, functional foods have become more important in preventive healthcare [5]. Plant-based bioactive chemicals include immunomodulatory, anti-inflammatory, and antioxidant properties that help prevent illness and maintain health [6]. A viable method for creating nutraceuticals with increased therapeutic potential is the integration of medicinal plant extracts into food matrices [7].

2. Chocolate as Drug Delivery System (NDDS Perspective):

Due to its great patient acceptance and palatability, chocolate has lately been investigated as a new medication delivery strategy, especially for paediatric and geriatric populations [8]. Bioactive substances, particularly those with disagreeable e taste characteristics, are effectively transported by it. Chocolate's high lipid content makes it easier to incorporate lipophilic medications and increases their absorption [9].

Taste masking, which is particularly crucial for bitter herbal medications like Andrographis paniculata, is one of the main benefits of chocolate-based delivery methods [10]. In paediatric patients, who frequently reject conventional dosage forms, the pleasant taste and texture enhance patient compliance [11]. Furthermore, the lipid matrix of chocolate facilitates lipophilic drug transport, which improves the stability and absorption of bioactive substances [12]. Therefore, medicated chocolates are a promising and patient-friendly dose form that combines better organoleptic qualities with therapeutic effectiveness [13].

3 Papaya Leaf Overview:

Flavonoids, alkaloids, phenolic compounds, enzymes like papain, and vital vitamins are among the many bioactive substances found in papaya (*Carica papaya*) leaves [14]. The plant's varied pharmacological actions are a result of these phytoconstituents. Research has shown that papaya leaves have high concentrations of flavonoids and phenolics, which are essential for scavenging free radicals and lowering oxidative stress [15].

Papaya leaves have a variety of medicinal properties. Because of their high polyphenolic content, they have antioxidant qualities [16]. By boosting immunological responses and bolstering host defensive systems, they also exhibit immunomodulatory effects [17]. The capacity of papaya leaf extracts to raise platelet counts has been extensively researched,

Figure 1: Papaya leaf extract

especially in diseases like dengue fever [18]. These characteristics demonstrate their potential use in nutraceutical and functional food compositions.

4.Kalmegh Overview:

Known as the "King of Bitters," Kalmegh *(Andrographis paniculata)* is a significant medicinal plant utilized in ancient medical systems including Ayurveda and ancient Chinese Medicine [19]. Andrographolide, a diterpenoid lactone, is the main bioactive component that gives it its medicinal properties.

Hepatoprotective, anti-inflammatory, and immunomodulatory properties are among the several pharmacological actions of kalmegh [20]. Additionally, it has been claimed to have antiviral, anticancer, antibacterial, and antioxidant qualities. Its extremely bitter taste restricts its direct eating despite its considerable medical benefit, requiring the creation of pleasant administration methods.

Figure 2: Kalmegh leaf extract

5.Rationale of Study:

The strong bitterness of papaya and kalmegh leaves limits their direct usage in oral formulations and food items, despite their significant medicinal advantages. Achieving patient acceptance and compliance is difficult as a result, especially in paediatric populations.

By serving as a transporter of nutraceuticals and a taste-masking agent, chocolate provides an efficient option. It is a perfect carrier for delivering plant extracts because of its pleasant character and capacity to integrate bioactive ingredients. Furthermore, few research have examined the combined use of papaya and kalmegh in chocolate formulations as functional meals, despite the fact that individual studies have investigated their medicinal qualities. In order to combine increased nutritional value with better patient acceptance, this study intends to create and assess herbal chocolate that contains papaya and kalmegh leaves.

Objectives

The present study is designed to develop and evaluate a novel nutraceutical formulation by incorporating medicinal plant materials into a chocolate matrix. The specific objectives of the study are as follows:

1 Formulation of Herbal Chocolate

Using appropriate excipients such cocoa butter, cocoa powder, and emulsifiers, make herbal chocolate using powdered papaya (*Carica papaya*) and kalmegh (*Andrographis paniculata*) leaves. Because of its great acceptance and capacity to include functional elements, chocolate has been extensively studied as a potential transporter for bioactive substances. It has been observed that creating nutraceutical chocolate formulations enhanced with herbal extracts is a successful strategy for enhancing health benefits without sacrificing flavour.

2 Evaluation of Physicochemical Properties

to assess the chocolates' physicochemical properties, including their pH, hardness, melting point, moisture content, and texture. These factors are crucial in establishing the stability, quality, and shelf life of a product. Research on functional chocolates has shown that rheological and physicochemical qualities are greatly impacted by the addition of plant-based substances.

3 Sensory Evaluation

Using a hedonic scale, evaluate the produced herbal chocolates' sensory qualities, including flavour, scent, texture, appearance, and general acceptance. Determining customer acceptability and improving formulation factors need sensory evaluation. Prior research has demonstrated that while larger concentrations of herbal compounds may adversely influence flavour and texture, moderate inclusion of these constituents in chocolate produces acceptable sensory qualities.

4 Determination of Antioxidant Activity

to use common tests like FRAP and DPPH to assess the chocolates' antioxidant activity. The bioactive profile of chocolate is further enhanced by the inclusion of plant extracts, and the chocolate itself includes polyphenols with antioxidant qualities. Research has shown that adding plant-based or herbal substances to chocolate greatly boosts its phenolic content and antioxidant activity.

5 Assessment as Functional Nutraceutical

to assess the herbal chocolate's potential as a useful nutraceutical product. It has been demonstrated that functional chocolates enhanced with herbal bioactive increase consumer compliance, offer therapeutic advantages, and boostnutritional value. Particularly in paediatric and elderly populations, these formulations can function as novel bioactive chemical delivery vehicles.

Literature Review

Table 1: Literature Review

	Biological Source	Active Compounds	Pharmacological Profile	Use in Ayurveda
Papaya leaf extract	The Caricaceae family includes the papaya (Carica papaya L.), which is extensively grown in tropical and subtropical climates. Traditional medical systems have made considerable use of the plant's leaves to cure a variety of illnesses, such as infections, inflammation, and metabolic abnormalities.	Numerous phytoconstituents, including flavonoids, alkaloids (carpaine), phenolic compounds, tannins, glycosides, saponins, and enzymes like papain, are abundant in papaya leaves [3,4]. Their antioxidant and medicinal potential are greatly enhanced by these substances. Strong free radical scavenging activity and oxidative stress protection are caused by high phenolic and flavonoid concentrations.	Papaya leaf extract dramatically raises platelet counts in dengue patients, aiding in the treatment of thrombocytopenia, according to a number of clinical and preclinical investigations. By increasing platelet synthesis and stabilizing cell membranes, the alkaloid carpaine and other bioactive substances are thought to contribute to this action.	Papaya leaves have a variety of pharmacological properties, including as immunomodulatory, antibacterial, anti-inflammatory, and antioxidant actions. Additionally, they are known to have gastroprotective, hepatoprotective, and hypoglycaemic qualities, which make them helpful in the treatment of chronic illnesses.
Kalmegh	Ayurveda and Traditional Chinese Medicine both make extensive use of Andrographis paniculata (Kalmegh), a member of the Acanthaceae family, as a medicinal herb.	Andrographolide, a diterpenoid lactone, is the main bioactive component of Kalmegh. Flavonoids, diterpenoids, and polyphenols are additional substances that support its pharmacological actions.	Hepatoprotective, anti-inflammatory, antioxidant, antibacterial, and immunomodulatory properties are only a few of the many pharmacological actions of kalmegh. Its function in protecting the liver and boosting the immune system has been extensively researched.	Kalmegh has long been utilized in Ayurveda medicine to treat inflammation, fever, liver problems, and infections. It is frequently made into pleasant dose forms to increase patient compliance because of its extremely harsh taste.

Chocolate as Functional Food (Compound Chocolate Context)

Cocoa Phytochemicals

Bioactive substances such polyphenols, theobromine, and flavonoids (epicatechin, catechin) are found in chocolate, especially in cocoa-based goods. These substances contribute to the health benefits of chocolate and have potent antioxidant qualities.

Health Benefits

Chocolate consumption has been linked to a number of health advantages, such as better cardiovascular health, decreased oxidative stress, increased cognitive function, and anti-inflammatory properties. It is well known that cocoa polyphenols lower the risk of chronic illnesses and enhance endothelial function.

Use as Carrier System

Because of its affordability, simplicity of processing, and stability, compound chocolate—which substitutes vegetable lipids for cocoa butter—is frequently utilized in functional food compositions. It maintains acceptable sensory qualities while acting as an efficient transport mechanism for adding bioactive plant elements. Its pleasant texture and lipid matrix enhance absorption and make lipophilic drugs easier to administer.

Herbal Chocolates (Previous Work)

Studies on Herbal/Functional Chocolates

The use of plant-based components and herbal extracts in chocolate formulations to improve its functional qualities has been the subject of several research. It has been demonstrated that adding plant extracts to food greatly increases its nutritional content and antioxidant activity.

Taste Masking Approaches

The bitter taste of plant extracts is one of the main issues with herbal compositions. Because of their creamy texture and sweet flavour, chocolate matrices—especially compound chocolate—have been effectively employed as taste-masking systems. Particularly in paediatric formulations, this enhances patient acceptance.

Nutraceutical Confectionery Trends

A new trend in the food and pharmaceutical sectors is the creation of nutraceutical confections, such as herbal chocolates. These products are appropriate for preventative healthcare and wellness applications since they combine therapeutic effects with convenient dosing forms.

Materials and Methods

Every ingredient used to make herbal chocolate was of food-grade or analytical quality and came from reputable suppliers.

A standardized herbal raw material provider provided papaya leaf powder (Carica papaya), which was verified using both macroscopic and microscopic features. Papaya leaves have been shown to increase platelet counts in diseases like dengue-induced thrombocytopenia because they contain bioactive substances including flavonoids, alkaloids, and phenolic compounds.

We purchased kalmegh powder (*Andrographis paniculata*) from a reputable source of Ayurvedic raw medicines. The plant is well-known for its immunomodulatory, hepatoprotective, and anti-inflammatory qualities and is rich in diterpenoids like andrographolide, which makes it appropriate for use in functional formulations.

A verified food-grade provider (such as a nearby commercial supplier or an institutional procurement unit) provided the cocoa powder, cocoa butter, dates syrup, and milk powder. Flavonoids and bioactive polyphenols, which are abundant in substances derived from cocoa, add to the formulation's antioxidant and cardioprotective qualities and improve its functional value.

Dates syrup was used as a sweetener to cover up the bitter taste of the herbal ingredients, and milk powder was added to enhance the chocolate formulation's organoleptic qualities and nutritional profile.

Date syrup was used as a natural sweetener and taste-masker in addition to traditional sweeteners. Because date syrup contains natural sugars, minerals, and antioxidants, it not only increases the nutraceutical value but also improves palatability by lessening the harshness of herbal ingredients. By substituting a functional ingredient for refined sugar, this method introduces originality to the formulation.

The formulation's desired texture, melting properties, and stability were achieved by using cocoa butter and nutmeg butter as lipid basis. Additionally, lipid excipients are crucial for increasing the bioavailability of lipophilic phytoconstituents.

When necessary, sodium benzoate was added as a preservative to guarantee the formulation's microbiological stability. Before being used again, all items were kept in a cold, dry location that was shielded from light.

Preparation of Leaf Powder

To maintain phytoconstituents and guarantee consistency in the formulation, papaya (*Carica papaya*) and kalmegh (*Andrographis paniculata*) leaf powders were made using a standardized process.

1.Collection

Fresh Andrographis paniculata and Carica papaya leaves were gathered from a nearby agricultural source and verified using morphological traits. The bioactive profile of medicinal plants is greatly influenced by environmental factors; hence the collection was done within the right seasonal circumstances to ensure maximal phytochemical content.

2.Washing

To get rid of dust, dirt particles, and microbiological pollutants, the gathered leaves were carefully cleaned with distilled water. In order to minimize surface contaminants and guarantee the final herbal product's safety and quality, proper washing is crucial.

3.Shade Drying

After washing, the leaves were shade-dried for a few days at room temperature (25–30°C) until all moisture was removed. For medicinal plants, shade drying is favoured since it reduces the deterioration of heat-sensitive phytoconstituents such flavonoids, alkaloids, and essential oils. Additionally, it keeps volatile chemicals from being lost and aids in maintaining antioxidant activity.

4.Pulverization

To get a consistent particle size, the dried leaves were coarsely ground using a mechanical grinder and then put through an appropriate sieve (such as sieve number 60). By increasing the surface area, pulverization improves the formulation's active ingredients' uniform distribution and extraction efficiency.

5.Storage

The prepared leaf powders were stored in airtight containers, protected from light, moisture, and contamination, at room temperature. Proper storage conditions are crucial to maintain stability, prevent microbial growth, and preserve the pharmacological activity of the herbal materials.

Formulation design

Table 2: Formulation Table

Ingredients	Quantity taken
Kalmegh Leaf Powder	1.0 g
Pappaya Leaf Powder	0.5 g
Cocoa Powder	0.8 g
Cocoa Butter	1.0 g
Normal Butter	1.0 g
Milk Powder	1.2 g
Date syrup	2.5 g
Sodium Benzoate	0.04 g

Preparation Method

A standardized procedure based on traditional chocolate processing methods was used to create the herbal chocolate formulation, with minor adjustments made to incorporate herbal powders.

1.Double Boiler Method:

The double boiler process, which involves indirectly melting cocoa butter by putting it in a container over a water bath kept at a regulated temperature (~40–50°C), was used to create the basic chocolate mass. This technique guarantees consistent heating and shields cocoa butter from burning or direct thermal deterioration. In order to preserve the desired polymorphic form of cocoa butter, which affects the texture, gloss, and melting properties of chocolate, controlled melting is necessary for appropriate crystallization behaviour.

Figure 2 double boiling method

2.Mixing

To create a homogenous chocolate mass, cocoa powder, milk powder, and dates syrup were added gradually and constantly after the cocoa butter had completely melted. In order to ensure even dispersion throughout the chocolate matrix, date syrup was added during mixing as a natural sweetener and taste-masking agent. Its viscosity also enhanced the mouthfeel and texture.

In the production of chocolate, mixing is essential because it guarantees that solid particles are evenly distributed throughout the fat phase. In order to achieve a smooth texture and desired consistency, effective mixing reduces particle aggregation and enhances rheological qualities.

3. Addition of Herbal Powders

Under constant stirring, the prepared papaya leaf powder (*Carica papaya*) and kalmegh powder (*Andrographis paniculata*) were mixed into the melted chocolate mixture. To prevent lump formation and guarantee even distribution, the granules were applied gradually. Herbal powders can be added to lipid-based matrices to improve the distribution of bioactive chemicals while disguising their natural bitterness. For the final formulation to remain consistent and avoid phase separati on, proper dispersion is crucial.

Figure 3 Mixing

4.Molding and Cooling

After being cleaned, the uniform chocolate mixture was put into moulds and allowed to cool under regulated conditions. The moulds were first allowed to cool at ambient temperature before being refrigerated for full solidification at around 8 to 10°C.

In order to generate stable β-crystals that give chocolate its desired hardness, snap, and glossy look, cooling is essential to the crystallization of cocoa butter. In addition to preventing flaws

Figure 4 Molding and cooling

like fat bloom, proper chilling conditions guarantee the final product's structural integrity. The chocolates were demoulded and kept in airtight containers under controlled circumstances for additional testing once they had fully solidified.

Formulation Optimization:

The concentrations of herbal powders and sweeteners (including date syrup) were varied to create a total of six or seven experimental formulations (F1–F7). The organoleptic qualities, texture, and general acceptability of each formulation were assessed.

An optimal formulation that demonstrated a balance between flavour masking, texture, and medicinal potential was chosen based on sensory evaluation and physicochemical criteria.

Table 3 optimization of herbal chocolate formulation

Formulation Code	Composition	Observation
F1	Dark chocolate + Papaya extract (1 g) + Kalmegh extract (1 g).	Very bitter taste, not palatable; good stability.
F2	Dark chocolate + Papaya extract (1 g) + Kalmegh extract (1 g) + Dates paste.	Bitterness masked to some extent; slightly bitter aftertaste; poor stability.
F3	Milk chocolate + White chocolate + Dates paste + Papaya extract (1 g) + Kalmegh extract (1 g)	Aftertaste masked; formulation unstable
F4	Milk chocolate + Dates paste + Papaya extract (1 g) + Kalmegh extract (1 g)	Not stable
F5	Dark compound chocolate + Milk chocolate + White chocolate + Dates paste + Papaya extract (1 g) + Kalmegh extract (1 g)	Slightly stable
F6 (OPTIMIZED)	**Dark compound chocolate + Date syrup + Papaya extract (1 g) + Kalmegh extract (1 g)**	**Highly stable; bitterness completely masked; best formulation selected**
F7	Milk chocolate + White chocolate + Date syrup + Papaya extract (1 g) + Kalmegh extract (1 g)	Unstable
F8	Milk chocolate + Date syrup + Papaya extract (1 g) + Kalmegh extract (1 g)	Unstable
F9	Dark compound chocolate + White chocolate + Milk chocolate + Date syrup + Papaya extract (1 g) + Kalmegh extract (1 g)	Unstable

To ensure consistency in therapeutic potential, all formulations were made using a set concentration of 1 g papaya extract and 1 g kalmegh extract. The type of chocolate foundation and sweetening/taste-masking ingredients like date syrup and paste were the main causes of the variances.

The efficiency of date syrup as a novel taste-masking and stabilizing ingredient in herbal chocolate formulations was demonstrated when F6 was chosen as the optimal formulation out of all the formulations because of its exceptional stability and total bitterness masking.

Evaluation of herbal Chocolate

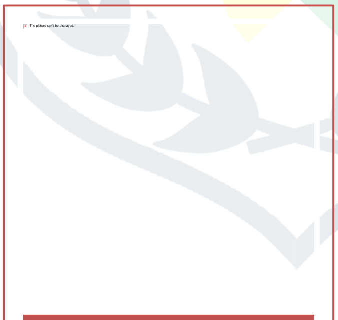
1.Organoleptic Evaluation

Colour	Dark Brown
Taste	Slightly Bitter
Texture	Non – Streak
Aroma	Sweet

2.Physicochemical Evaluation.

pH	6.16
Weight Variation	±5–10%
Hardness	5 kg
Melting point	30–35°C
Moisture content	~1–2%s


HARDNESS TEST


pH TEST


MOISTURE CONTENT

3.Sensory Evaluation

3.1 Panel Selection

Sensory evaluation of all formulations (F1–F9) was carried out using a **semi-trained panel** consisting of **10–15 members** (students and faculty from pharmacy background).

- Inclusion criteria:
  - Healthy individuals
  - Non-smokers

- No known taste or olfactory disorders
- Panellists were briefed about:
  - Evaluation parameters
  - Scoring method
  - Rinsing mouth with water between samples

3.2. Evaluation Parameters

Each formulation was evaluated based on:

- Taste (bitterness masking)
- Aroma
- Texture (mouthfeel)
- Appearance
- Overall acceptability

3.3 Hedonic Scale Method

A **9-point hedonic scale** was used:

Score	Interpretation
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

3.4 Sensory Evaluation Results (Interpretation)

- **F1**: Very low score due to intense bitterness → *Not acceptable*
- **F2**: Slight improvement due to dates paste → *Moderate acceptability*
- **F3 & F4**: Poor texture and instability → *Rejected*
- **F5**: Slightly acceptable but inconsistent texture
- **F6 (Optimized)**:
  - Highest scores in all parameters
  - Bitterness completely masked
  - Smooth texture and pleasant taste
  - **Selected as best formulation**

- **F7–F9**: Poor stability led to low sensory scores

3.5Conclusion of Sensory Study:

The sensory evaluation clearly demonstrated that **date syrup/paste acts as an effective natural taste masking agent**, and **F6 showed maximum overall acceptability**, making it suitable for further development as a nutraceutical chocolate.

4.Stability Studies

4.1 Study Design

Stability studies were conducted for all formulations as per **ICH guidelines (adapted for food/nutraceutical products)**.

4.1Storage Conditions:

- **Room temperature**: 25°C ± 2°C
- **Accelerated condition**: 40°C ± 2°C, 75% RH

1. **Study Duration:**

- 0, 7, 15, and 30 days

4.2 Evaluation Parameters

At each interval, formulations were evaluated for:

- Physical appearance (colour, bloom formation)
- Texture (hardness/softening)
- Taste changes
- Phase separation
- Stability of herbal incorporation

4.3 Stability Results:

- **F1**: Good stability but unacceptable taste
- **F2**: Poor stability (likely due to moisture from dates paste)
- **F3–F4**: Completely unstable (phase separation observed)
- **F5**: Slight stability but not ideal
- **F6 (Optimized)**:
  - **Highly stable under all conditions**
  - No phase separation
  - No significant change in taste or texture
  - Maintained structural integrity
- **F7–F9**:
  - Unstable due to:
    - Addition of milk chocolate and white chocolate in the formulations
    - Moisture incompatibility with chocolate matrix

4.5 Stability Conclusion

- The optimized formulation **F6 demonstrated superior physicochemical stability and sensory acceptability**, making it the **ideal formulation for further development and commercialization**.

Discussion

The formulation of herbal chocolate using Carica papaya and Andrographis paniculata was effectively proven in this work, underscoring its potential as a new nutraceutical delivery mechanism. Because of its great acceptance and capacity to cover up bad taste while preserving the stability of bioactive chemicals, chocolate-based systems have been investigated more and more as carriers for herbal actives.

The formulation's palatability was greatly enhanced by the inclusion of date syrup as a natural taste-masking agent. Date syrup had more nutritional advantages and improved sensory acceptability as compared to traditional sweeteners. Its potential as a functional excipient in nutraceutical chocolate compositions is highlighted by this.

1.Interpretation of Results:

The produced formulations had acceptable physicochemical and sensory qualities, according to evaluation criteria including appearance, texture, melting behaviour, and overall acceptability. While cocoa polyphenols offered extra antioxidant advantages, the presence of cocoa butter helped to the desired crystallization and mouthfeel.

The structural integrity of the chocolate matrix was not substantially affected by the addition of herbal powders, suggesting that plant-derived powders and lipid bases are compatible. Studies that successfully added herbal extracts to chocolate without negatively impacting stability have revealed similar results.

2. Effect of Herbal Concentration: Taste vs Health Benefit Trade-off:

The study's key finding was that herbal concentration and sensory acceptance were inversely correlated. As papaya leaf and kalmegh powder concentrations rose

a. Astringency and bitterness increased
b. Palatability declined
c. Decreased consumer acceptance

This is explained by the presence of phytochemicals that give food a pronounced bitter taste, such as polyphenols and alkaloids. The inclusion of herbal powders exacerbates the bitterness caused by the polyphenols found in cocoa.

However, the therapeutic potential is enhanced by higher herbal concentration, especially:

Papaya leaves → action that enhances platelets Immunomodulatory and anti-inflammatory properties of Kalmegh

Therefore, the composition of functional foods must strike the ideal balance between sensory attractiveness and medicinal efficacy.

Comparison with Previous Studies

The results of this investigation align with earlier studies on herbal chocolates:

- Studies on chocolate enhanced with papaya leaves found that when bitterness was covered up with flavouring ingredients, the chocolate's health advantages increased and its sensory qualities were acceptable.

- Similar patterns were seen with herbal chocolates made with guava and bael leaves, where a higher herbal content enhanced functional qualities but decreased palatability.
- Plant extract-based nutraceutical chocolate systems showed enhanced antioxidant qualities and efficient bioactive chemical delivery.

Additionally, because chocolate is easier to administer and improves compliance, it has been generally acknowledged as a good medicine delivery medium, especially for paediatric and geriatric populations.

The current study supports the idea of functional foods and nutraceuticals, which are food items made with both nutritional value and health advantages in mind.

Conclusion

The creation and assessment of an herbal chocolate using Andrographis paniculata and Carica papaya as a novel nutraceutical dosage form was effectively proven in this study. The formulation strategy improved the acceptability and stability of herbal bioactive by using chocolate as a palatable lipid-based delivery method.

Because cocoa polyphenols and herbal phytoconstituents work in concert, the proposed formulations showed enhanced antioxidant activity. It is commonly known that cocoa is a rich source of polyphenolic chemicals including catechins and epicatechins, which have important antioxidant and free radical scavenging qualities.

Additionally, research has demonstrated that chocolate and cocoa-based products contain quantifiable phenolic content and antiradical activity, supporting their function as functional antioxidant carriers**.**

The formulation's total functional value was increased by the inclusion of papaya leaf and kalmegh powders, which provided additional therapeutic advantages such immunomodulatory and platelet-enhancing qualities. The produced formulations retained an acceptable sensory profile despite the inclusion of naturally bitter phytoconstituents, proving that chocolate may effectively conceal disagreeable taste while maintaining bioactivity.

Higher concentrations of herbal powders resulted in greater bitterness and decreased consumer acceptance, therefore striking a balance between herbal concentration and palatability was crucial. This result is consistent with previous research, which emphasizes that although cocoa and herbal polyphenols offer health advantages, their sensory impact needs to be maximized for effective formulation.

A unique strategy that improves the herbal chocolate's therapeutic value and sensory acceptance is the use of date syrup as a natural sweetener and taste-masking agent.

The study's overall findings support the potential of herbal chocolate as a functional food system and nutraceutical, providing both therapeutic efficacy and patient compliance. These formulations might be used as an alternative to traditional dose forms, in paediatric and geriatric nutrition, and in preventative healthcare.

Future research should focus on:

- Clinical evaluation of therapeutic efficacy
- Stability studies and shelf-life assessment
- Optimization of herbal concentration for maximum benefit
- Scale-up and commercialization potential

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