FABRICATION OF MEDICATED CHOCOLATE BY USING ANDROGRAPHIS PANICULATA

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ABSTRACT

Andrographis paniculata is referred to as the "King of bitters." It contains various essential components, including diterpenes, lactones, andrographolide, and flavonoids, which are renowned for their biological actions as antioxidants, anti-inflammatories, and antiseptics. It also has a therapeutic role in human disorders. Chocolate has long been associated with its delicious flavour and potential health benefits. In this study, various formulations were used to create medicated chocolate with the therapeutic qualities of Andrographis paniculata. FTIR analysis revealed that a paniculata powder and medicated chocolate share the same functional group, which represents chemicals such as flavonoids, lactones, and so on. Sensory analysis was conducted. The nutritional study was performed to verify the nutritional value of this medicated chocolate.

Keywords— Andrographis paniculata, lactones, flavonoids, Chocolate, medicated chocolate.

I.INTRODUCTION

The scientific name of the fruit from the angiosperm tree is “Theobroma Cacao,” meaning “food of the gods.” Cocoa bean utilization dates back at least 1400 years, with the Aztecs and Incas valuing the beans as currency and crafting a chocolate drink from roasted and ground cocoa nibs mixed with water and other ingredients like vanilla, spices, or honey. The chocolate drink later spread to Spain, sweetened heavily for nobility and kept secret until it became popular across Europe thanks to Conquistadors. Initially enjoyed by the elite, chocolate consumption expanded significantly in the 18th century, leading to the establishment of plantations by Italians, Dutch, and Portuguese as the Spanish monopoly weakened. Chocolate, primarily consumed in liquid form, was sold as blocks to be dissolved in water or milk.

Chocolate is typically sweet and brown, produced from the seeds of the cacao tree, which are fermented for flavor development, dried, cleaned, roasted, and processed into nibs, cocoa mass, and finally chocolate by heating. This chocolate liquor can be further processed into cocoa solids and cocoa butter, forming the basis of various chocolate products. Today, chocolate is a widely celebrated food and flavor, incorporated into candies, bars, and snacks.

1.1 VARIETIES OF CHOCOLATE

Figure 1 Various types of chocolate

- Milk Chocolate: Developed in 1875 by Daniel Peter and Henri Nestle, it requires a minimum of 25% cocoa solids in the U.S. However, an agreement in 2000 allowed "family milk chocolate" in the UK, Ireland, and Malta to contain only 20% cocoa solids.
- Dark Chocolate: Also known as "Plain" or "Black chocolate", it has a higher cocoa percentage and does not contain milk. Varieties include bittersweet and extra dark, with cocoa percentages ranging from 70%-90%.
- White Chocolate: Made from sugar, milk, and cocoa butter without cocoa solids. It contains trace amounts of theobromine and caffeine and may have flavorings like vanilla.
- Organic Chocolate: Certified organic, made from cocoa and sugar without harmful chemicals.
- Raw Chocolate: Unprocessed and unheated chocolate, marketed as healthy, mainly sold in chocolate-producing countries.
- Unsweetened Chocolate: Pure chocolate with some fat, used for baking and confections, known for its deep chocolate flavor.
- Bittersweet Chocolate: Contains sugars, cocoa butter, and flavorings, interchangeable with semisweet chocolate in baking. The cocoa percentage influences sweetness.
- Semisweet chocolate: This chocolate frequently used for cooking purposes. It's semi-sweet chocolate with 0.5 the maximum amount of sugar as cocoa on the far side that it's “sweet chocolate”. Bittersweet chocolate doesn't contain milk solids.
- Compound chocolate: It is the technical term for a confection combining cocoa with vegetable fat, generally tropical fats, or alter fats as a replacement for cocoa butter. It’s generally used for candy coatings.
- Modeling chocolate: It is a chocolate paste created by melting chocolate combing it with corn syrup, glucose syrup or golden syrup. It is primarily utilized by upmarket

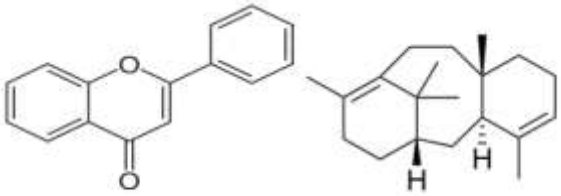
cake makers and patisseries to add decoration to cakes and pastries. Flavours like mint, vanilla, coffee, orange, or strawberry unit of measurement are usually supplementary to a chocolate creamy kind or in terribly little things. Chocolate bars frequently contains ingredients like peanuts, nuts, fruit, caramel, and crisped rice. Pieces of chocolate in various flavours are sometimes added to cereals and ice creams.

1.2 ANDROGRAPHIS PANICULATA

The plant, known as "King of bitters" or Nilavembu, is an erect herb reaching 30-110 cm in height, found in wet, shady areas. It features a dark, slender stem, lance-shaped leaves, and small pink flowers arranged in lax racemes. Its capsule fruit contains numerous yellow-brown seeds. This Siddha herb is renowned for its immune-enhancing properties, including anti-pyretic, cholagogue, digestive, hepatoprotective, and anti-inflammatory effects. Historically used in Ayurvedic, Siddha, Unani, homeopathic, Chinese medicine, and folk remedies, it is especially effective against intermittent fevers like those from infections, dengue, and Chikungunya. It also promotes liver health, stimulates digestion, enhances appetite, and combats various ailments including blood disorders and skin diseases.

Table 1 scientific classification

Scientific name	***Andrographis paniculata***
Kingdom	Plantae
Class	Tracheophytes Angiosperms Eudicots Asterids
Order	Lamiales
Family	Acanthaceae
Genus	Andrographis
Species	A. paniculata



Flavonoid Diterpene

Figure 2 Chemical Component

II.LITERATURE SURVEY

2.1 Omer Said Toker et al, [1].

This study explores the quality of chocolate in relation to its unique flavors, influenced by both non-volatile and volatile compounds. The aroma is affected by environmental conditions, fermentation, drying, and manufacturing processes. It establishes a relationship between chemical compounds, cocoa flavor, post-harvest practices, and processing methods necessary for different chocolate characteristics. Instrumental experiments like aroma extraction and

sensory extraction are mentioned. Additionally, it notes the unpleasant taste of raw cocoa, emphasizing the importance of fermentation, drying (including sun drying), and roasting in flavor development. Factors influencing chocolate flavor include cacao growth, processing, and post-harvest treatments, alongside physical, chemical, and biological influences.

2.2 Soma Roy et al, [2].

This study examines the phytochemical profile and antimicrobial properties of Andrographis paniculata, using two extraction methods: chloroform and chloroform + HCl. Nine pathogenic bacterial strains were tested to compare antimicrobial efficacy. The chloroform extract exhibited superior antimicrobial activity against all strains. GC-MS analysis identified phenols, aromatic carboxylic acids, and esters in the chloroform extract as the active compounds, indicating that the pH of the extraction solvent does not significantly influence the extraction of antimicrobial phytochemicals.

2.3 Jaspreet Jain et al., [3].

This study explores the antiviral properties of NilavembuKudineer against dengue and chikungunya viruses, for which there are currently no vaccines or specific treatments available. The Siddha system presents Nilavembu as a successful polyherbal formulation for these infections. The research highlights the importance of extraction processes to enhance the drug's efficacy, revealing that NilavembuKudineer's mechanisms include preventing viral entry into cells and relying on cellular drug availability to maximize protection against both viruses.

2.4 Ruth Vanderschueren et al,. [4].

This study explores the use of elemental fingerprinting to trace the origin of cacao in chocolate, highlighting that 12% of sampled chocolates exceeded the Cadmium concentration limit for the European market. The findings indicate that trace elements are primarily associated with raw cacao rather than other ingredients or processing methods**.**

III.METHODOLOGY

3.1 Processes

- The preparation of chocolate begins with a formulation table for 100g, listing ingredients: cocoa powder, milk powder, milk butter, sugar, water, soya lecithin, and herbal powder.
- Ingredients are sieved to remove large particles, ensuring a finer texture.
- Each ingredient is measured on a weighing balance in 100g portions, with unmeasured ingredients stored tightly.
- Sugar syrup is prepared by mixing measured sugar and water in a water bath, stirred until fully melted.

- Milk butter is heated in the water bath until melted, then sugar syrup and soya lecithin (an emulsifier) are added, improving viscosity.
- Cocoa powder and milk powder are incorporated and continuously stirred until a creamy texture is achieved.
- The mixture is cooled at room temperature and poured into molds for shaping, with formulations repeated until a satisfactory product is developed.
- The molded chocolate is tasted to evaluate its quality, leading to further formulations as needed.

3.2 FTIR analysis

Fourier Transform infrared spectroscopy (FTIR) is a technique used to obtain the infrared spectrum of absorption or emission of solids, liquids, or gases. An FTIR spectrometer collects high-resolution spectral data across a wide range, measuring the amount of light absorbed by a sample at each wavelength. This method is applied to analyze formulated chocolate and powder to identify the present functional groups.

Figure 3 FTIR Spectroscopy

3.3 Sensory Anlaysis

SENSORY PROPERTIES	SCORE	DESCRIPTION OF EVALUATED PROPERTY
Appearance Form, brightness, Colour, surface	5	Smooth, bright surface, clear print, appropriate form, irreproachable colour
	4	Smooth, bright colour, print less clear, insignificant deviation of form
	3	Low quality of colour, air bubbles, fingerprints on surface, deviation of form
	2	More pronounced form of deviation, presence of cuttings, white gray surface
	1	Form distorted, gray or white, higher damages, print bad

SENSORY PROPERTIES	SCORE	DESCRIPTION OF EVALUATED PROPERTY
Texture Structure, break, firmness	5	Break straight, homogenous, fragile, structure homogenous, texture smooth, firmness appropriate
	4	Break uneven, structure, homogenous, firmness appropriate
	3	Break uneven, air bubbles, firmness inappropriate, fat bloom appearances on the break
	2	Break uneven, texture roughly-granular, fat bloom on the break
	1	Crumbling, texture roughly granular, fat bloom

Figure 4 Sample set 1

SENSORY PROPERTIES	SCORE	DESCRIPTION OF EVALUATED PROPERTY
Chewiness and other textural properties	5	Appropriate chewiness, melting in mouth
	4	Slower melting, good chewiness, spreadiness
	3	Average chewiness, spreadiness, weak sandiness
	2	Slow melting, stickiness
	1	Slow melting, heavy sandiness

SENSORY PROPERTIES	SCORE	DESCRIPTION OF EVALUATED PROPERTY
Aroma	5	Appropriate, rounded, aromatic
	4	Appropriate, poorer rounded, aromatic
	3	Appropriate, poor rounded, weakly aromatic
	2	Not appropriate, sourish, staled
	1	Foreign odour, mouldy, sour

SENSORY PROPERTIES	SCORE	DESCRIPTION OF EVALUATED PROPERTY
Odour Taste	5	Appropriate, rounded, aromatic
	4	Appropriate, less rounded, aromatic
	3	Poorly rounded, poorly aromatic
	2	Sourish, not rounded
	1	Sour, foreign taste , bitter

Figure 5 Sample set 2

3.4 Nutritional Analysis

1. **pH:** measures the acidity or alkalinity of a solution on a scale of 0 to 14, with 7 as neutral. It is crucial in food processing for maintaining product consistency, minimizing costs, ensuring consumer safety, and adhering to regulations. The pH is determined using a calibrated pH meter and electrode, following a procedure that includes rinsing the electrode, calibrating with buffer solutions, and measuring temperature. Accurate pH readings depend on repeating tests and reporting values to two decimal places. Proper rinsing and storage of the electrode are essential for accuracy.
2. **Moisture content:** moisture content food significantly affects taste, texture, appearance, shape, and weight, impacting legal labelling, shelf life, food quality, and processing. Optimal moisture levels are crucial to prevent microbial growth, which can spoil products and reduce freshness, affecting customer satisfaction and profits. This document outlines the importance of moisture analysis in the food industry and provides a standard operating procedure for moisture testing using a hot air oven, porcelain dish, silica or platinum, desiccators, and a weighing balance, ensuring accurate measurements by drying and weighing samples at controlled temperatures.
3. **Colour testing:** The Colour Benedict's reagent method is utilized to determine the colour of chocolate by dissolving 1.73g of copper sulphate in 10 ml of water and combining it with a solution made from 17.3g of disodium citrate and 10g of anhydrous sodium carbonate dissolved in 80 ml of water. This mixture is then diluted to 100 ml. For the test, 0.5 ml of the reagent is added to the sample and heated in a water bath at 100°C for 3 minutes. The presence of strong reducing agents like ascorbic acid produces red cuprous oxide. Weak responses are indicated by orange-brown colours from

substances such as streptomycin, while no colour appears from beclometasone and other specified compounds.

4. **Shelflife:** Foods are vital for life, and shelf life indicates their safety for consumption. Deterioration of processed foods can result from moisture changes, chemical and enzymatic activity, and microbiological spoilage. Moisture content is crucial, as excess water increases the risk of microbial growth and spoilage. Maintaining appropriate moisture levels enables producers to estimate shelf life accurately, ensuring consumer safety.
5. **Total fats:** The fat phase significantly influences chocolate quality, impacting properties such as rheology, release from the mold, snap, gloss, bloom prevention, melting characteristics, and flavor release. Milk fat and cocoa butter are the primary fats used. The apparatus for measuring fat content includes a thimble, hot air oven, desiccator, weighing balance, and Soxhlet extraction apparatus, utilizing petroleum ether as a solvent. The procedure involves weighing 10 to 30g of sample, drying it, and extracting fat using Soxhlet for 16 hours. The extract is dried, cooled, and weighed repeatedly until consistent mass loss is achieved, followed by determining fat acidity.
6. **Proteins:** This standard outline the Kjeldahl method for total nitrogen content determination, essential for calculating protein in foods and feed. The procedure involves the oxidation of the sample with sulfuric acid, converting nitrogen to ammonium sulfate, with mercury as a catalyst. Following digestion, distillation occurs where ammonia is released and absorbed in standard acid. The process requires precise measurements of reagents and careful temperature control to ensure accuracy. Key apparatus includes Kjeldahl flasks, hydrochloric/sulfuric acid, and sodium hydroxide solutions. Back-titration with standard alkali is performed to ascertain unreacted acid.
7. **Total Ash:** When organic material is burned, ash remains, comprising the inorganic content. To evaluate material quality, it is crucial to assess inorganic components. The process involves weighing approximately 5 g of the sample in a pre-weighed silica crucible, igniting it over a burner, and completing ignition in a muffle furnace at 550 ±20°C until a carbon-free ash is achieved. The crucible is then cooled in a desiccator and reweighed. This ignition and weighing process is repeated until the weight difference is less than 1 mg.
8. **Sugar:** This standard operating procedure outlines a method for determining total sugars in flour. Key solutions include acetate buffer (prepared from acetic acid, sodium acetate, and sulfuric acid), sodium tungstate, and alkaline ferric cyanide. The procedure involves placing 5.675 g of flour in an Erlenmeyer flask, wetting it with alcohol, adding acetate buffer, and mixing. For reducing sugars, a 5 ml extract is mixed with ferric cyanide, boiled, and titrated with Thio solution. Non-reducing sugars are determined similarly after hydrolysis. The results provide the amounts of reducing and non-reducing sugars calculated from the respective tables.
9. **Carbohydrates:** Carbohydrates are crucial components in various foods, existing either as physically associated or chemically bound to other molecules. They can be categorized based on the number of monomers into monosaccharides, oligosaccharides, or polysaccharides. This document outlines a method for determining carbohydrates in food products.

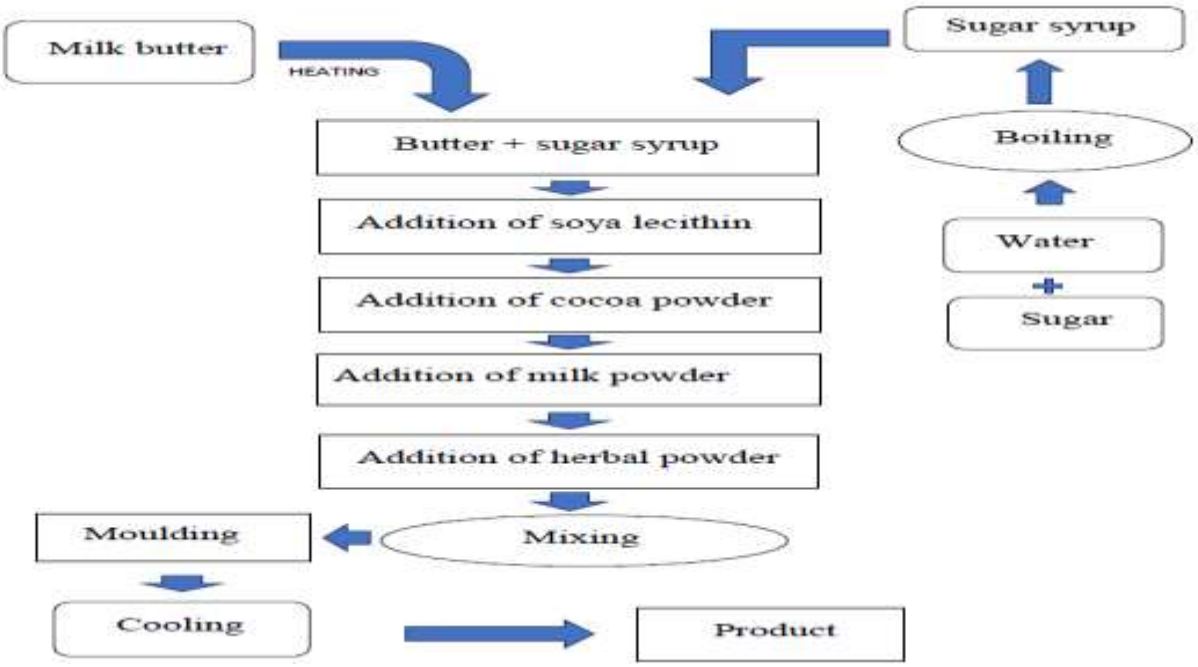


Figure 5 Flow diagram for fabrication of medicated chocolate by using andrographis paniculata.

IV. RESULT AND DISCUSSION

FTIR Analysis

Table 2- Formulation Table of Chocolate Sample.1 Given for Analysis

INGREDIENTS	g/100g	WEIGHT TAKEN
Cocoa powder	25	25
Milk powder	10	10
Water	19.9	19.9+1.99
Fat	10	10
Sugar	33	33
Soya lecithin	2	2
Powder	0.10	0.10

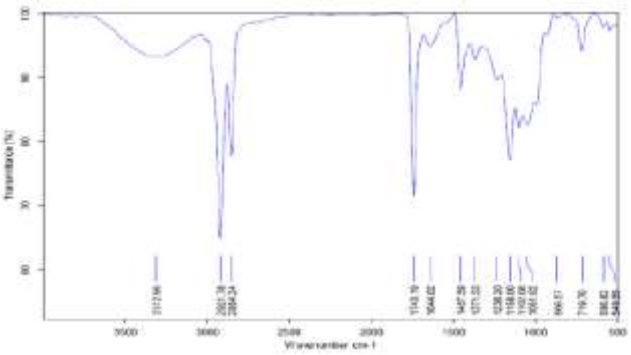
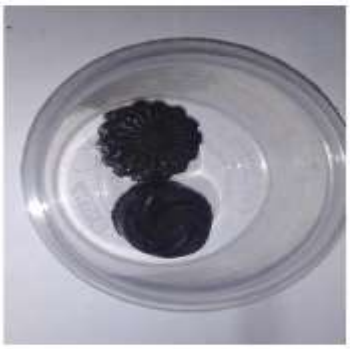


Figure 6 Sample 1 **Figure 7** FTIR spectrum of Medicated chocolate sample 1.

The chocolate sample contains several major compounds characterized by specific functional groups: primary amines, secondary amines, alkanes, alkenes, aliphatic amines, aromatic amines, C=O anhydride, carboxylic acid, and alkyl halides. Notable absorption peaks were observed at various wave numbers: 3312.95 cm^{-1} for alcohol, 2921.78 cm^{-1} for alkanes, 2854.2 cm^{-1} for alkenes, 1743.9 cm^{-1} for C=O anhydride, 1644.02 cm^{-1} for primary amines, 1371.53 cm^{-1} for aromatic amines, 1236.30 cm^{-1} and 1102.80 cm^{-1} for aliphatic amines, 866.57 cm^{-1} for carboxylic acid, and 719.70 cm^{-1} for alkyl halides.

Table 3- Formulation Table of Chocolate Sample.2 Given for Analysis

INGREDIENTS	g/100g	WEIGHT TAKEN
Cocoa powder	25	25
Milk powder	10	10
Water	19.80	21.70
Fat	10	10
Sugar	33	33
Soya lecithin	2	2
Powder	0.20	0.20



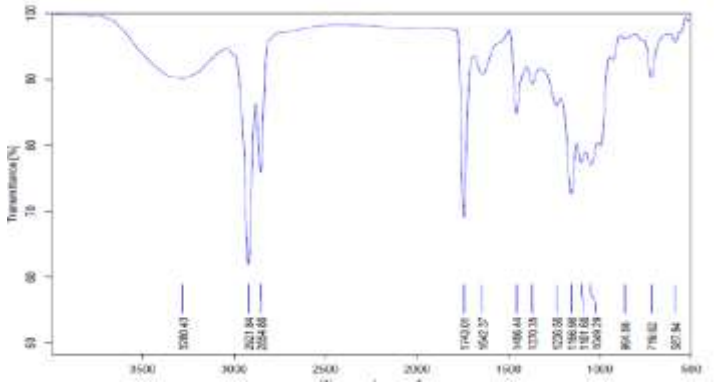


Figure 8 Sample 2 **Figure 9** FTIR spectrum of Medicated chocolate sample 2.

Major compounds identified in chocolate sample 2 include various functional groups: alcohols (OH stretch) at 3280.48 cm^{-1}, alkanes at 2921.84 cm^{-1}, alkenes at 2854.80 cm^{-1}, C=O anhydrides at 1743.01 cm^{-1}, primary amines at 1642.37 cm^{-1}, aromatic amines at 1370.35 cm^{-1}, aliphatic amines at 1236.58 cm^{-1} and 1102.60 cm^{-1}, carboxylic acids at 864.58 cm^{-1}, and alkyl halides at 719.02 cm^{-1}.

Table 4- Formulation Table of Chocolate Sample.3 Given for Analysis

INGREDIENTS	g/100g	WEIGHT TAKEN
Cocoa powder	25	25
Milk powder	10	10
Water	20.5	22.55
Fat	10	10
Sugar	33	33
Soya lecithin	1	1
Powder	0.50	0.50

Figure 10 Sample 3

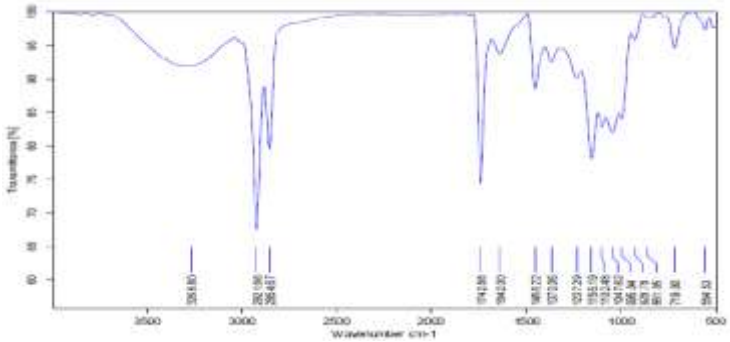


Figure 11 FTIR spectrum of Medicated chocolate sample 3.

In chocolate sample 3, several functional groups were identified, including alcohols (OH stretch at 3268.80 cm^{-1}), alkanes (2921.66 cm^{-1}), and alkenes (2854.80 cm^{-1}). The C=O anhydride group appeared at 1742.88 cm-1, while primary amines were observed at 1642.37 cm^{-1}. Aromatic amines showed peaks at 1370.06 cm^{-1}, and aliphatic amines were identified at 1237.29 cm^{-1} and 1102.48 cm^{-1}. The carboxylic acid functional group was detected at 995.04 cm^{-1}, and alkyl halides were noted at both 861.05 cm^{-1} and 719.00 cm^{-1}.

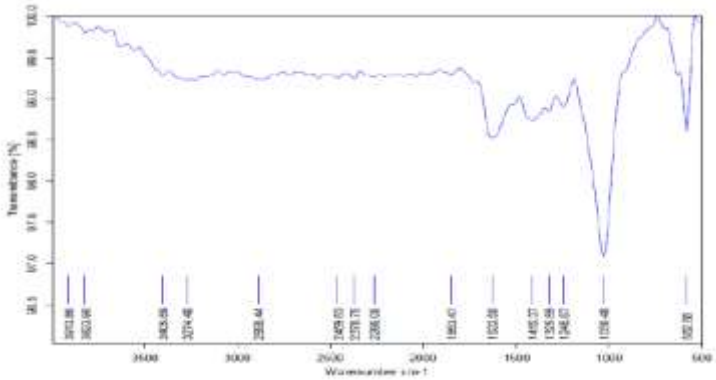


Figure 12 FTIR spectrum of Andrographis paniculata

The analysis of Andrographis paniculata reveals various functional groups, including alcohols, amines, alkanes, nitriles, and carboxylic acids. Key peaks at specific wave numbers indicate the presence of these compounds: 3823.90 cm^{-1} for phenolic OH stretching, 3274.48 cm^{-1} for alcohols, 2890.44 cm^{-1} for alkanes, 2266.05 cm^{-1} for nitriles, 1853.47 cm^{-1} for aromatic

compounds, 1633.50 cm^{-1} for primary amines, 1415.37 cm^{-1} for aromatic amines, 1245.69 cm-1 and 1030.48 cm^{-1} for aliphatic amines, and 582.68 cm^{-1} for alkyl halides.

Sensory Analysis

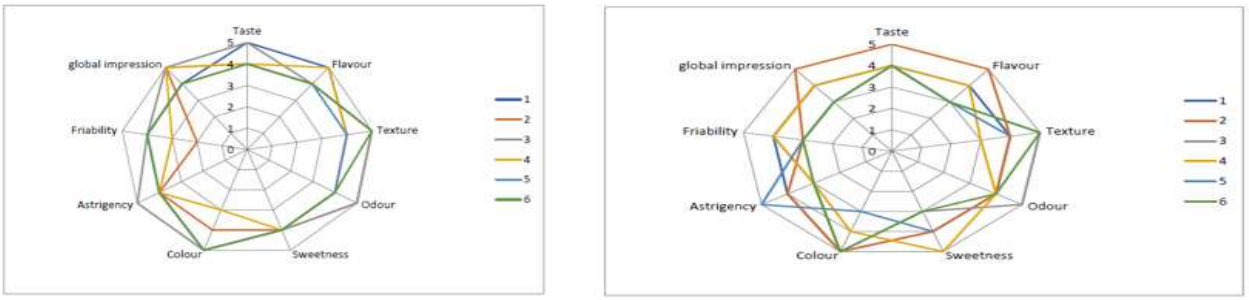


Figure 12 Sensory analysis of sample 1 ,2

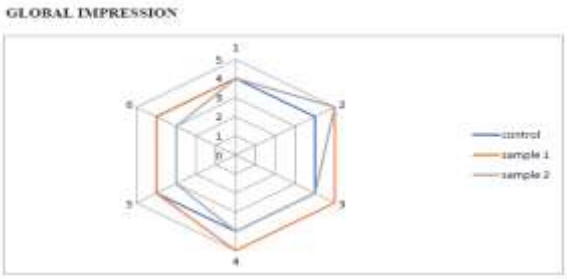


Figure 13 Global impression on sensory analysis

The sensory analysis evaluated three chocolate samples with varying concentrations of A. Paniculata powder. Samples, labeled Control, Sample 1, and Sample 2, were assessed for appearance, aroma, flavor, texture, and overall acceptance on a five-point scale. While sweetness, aroma, and texture differed significantly with varying herbal powder concentrations, brown color and creamy appearance did not change in perception. Notably, Sample 1 and Sample 2 showed significant differences in taste and sweetness, with consumer acceptance favoring Sample 1. Higher concentrations of the herbal powder were less preferred compared to lower concentrations.

Nutritional Value

The nutritional analysis of the formulated chocolate per 100g reveals a pH of 6.12 and a moisture content of 23.02g. The chocolate is dark brown in color, which is appealing to consumers. It contains 31.54g of fat, significantly impacting quality, affecting rheological properties, preventing blooms, and influencing melting and flavor. The protein content is 16.14g, with an ash content of 1.57g after organic materials are burnt. The sugar content is 22.3g, and carbohydrates amount to 27.73g. The solid fat content is 57%, and the energy value is approximately 457.65 KCals, indicating it as an energy-rich food.

V.CONCLUSION

Andrographis paniculata, a commonly utilized medicinal plant recognized for its therapeutic properties, has been integrated into chocolate to preserve its health benefits while reducing its natural bitterness. The study involved creating chocolate with A. Paniculata powder, resulting in three final formulations that were analyzed for functional groups. This showed that the chocolate contained alkanes, alkenes, aliphatic amines, aromatic amines, carboxylic acids, anhydride groups, and alkyl halides. Sensory analysis indicated positive reception of the chocolate, which underwent nutritional evaluation, revealing contents of 16.14 g protein, 31.54 g fat, 27.73 g carbohydrates, 1.57 g ash, 23.02 g moisture, and 457.06 kcal of energy. The results suggest the formulated chocolate is both effective and palatable.

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