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Research Article

Formulation and Evaluation of Anti-Diabetic Herbal Cookies

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ABSTRACT

The majority of individuals eat cookies for breakfast, snacks, and leisure in order to manage their hunger and obtain energy. There are many different types of cookies on the market, and their primary ingredients are butter, sugar, and refined ragi flour. Because they raise blood sugar levels, obese and diabetic people typically avoid these cookies. Thus, using oats, wheat flour, and various Ayurvedic herbs, we have created Polyherbal cookies for this study. To determine the ideal cookie composition based on palatability, several types were created utilizing various plants. Cookies were produced for physiochemical, sensory, and nutritional study once the optimal composition was chosen. Organoleptic properties were used to evaluate the sensory analysis. Sensory analysis was evaluated based on organoleptic property: colour, taste, aroma and overall acceptability on the basis of 9-pointhedonic scale. Physiochemical evaluation included total ash value, total water and alcoholic extraction, total moisture content. On the basis of nutritional value comparison, it was found that protein content is higher in our formulation than other products.

INTRODUCTION

Diabetes is a prevalent, non-communicable metabolic disease that primarily affects young people and is linked to other illnesses like kidney and cardiovascular disease. It happens when the pancreas fails to produce enough insulin or when the body does not use it effectively. An estimated 422 million persons worldwide suffered in 2014, with an increase rate of between 4.7% to 8.5%, according to a WHO study report. The symptoms of diabetes mellitus, a chronic metabolic disorder, include hyperglycaemia (high blood glucose), glycosuria, hyperlipidaemia, negative nitrogen balance, and occasionally ketonemia. In general, diabetes mellitus is divided into three classes: The primary cause of type-I diabetes mellitus, insulin-dependent diabetes mellitus, and juvenile onset diabetes mellitus is the autoimmune destruction of beta cells that secrete insulin by T-cells. Type 2 diabetes and non-insulin-resistant A significant

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decrease in κ-cell mass or poor insulin circulation brought on by a combination of metabolic or genetic factors can result in dependent diabetic mellitus. Type-2 diabetes affects about 90% of people with diabetes. Type 3 occurs when cells grow resistant to insulin or when insulin is not generated correctly during pregnancy. Insulin is a hypoglycaemic hormone made up of two polypeptides and fifty-one amino acids. The human pancreas secretes 1U of insulin each hour, but a greater amount is produced after meals and is regulated by hormonal, pharmacological, and neurological mechanisms.[1] All cell membranes contain insulin, although its density varies depending on the kind of cell; fat and liver cells have higher levels. The impact of insulin on metabolic enzymes is mediated by PI kinase, which is activated by certain secondary messengers such as PIP3. By transferring the glucose transporter (GLUT-4) to the plasma membrane in an ATP-dependent manner, insulin initiates glucose transport across cell membranes. GLUT-4 is assisted in its transition from the cytosol to the plasma membrane by the secondary messenger PIP3 and certain tyrosine phosphorylated guanine exchanger proteins. Diabetes and related diseases can be well treated with modern medications, but it would also be prudent to use natural diets, therapies, and lifestyle modifications. More than 1200 different plants, plant parts, and plant products have been found to be hypoglycaemic with few adverse effects. On April 7, 2016, World Health Day, which was devoted to diabetes, the first WHO Global Report on Diabetes was released. Although diabetes is acknowledged as a serious ailment and has been mentioned in ancient texts, doctors and healers do not seem to have encountered it often. The growing number of people with this ailment has had an increasing impact on human development and health in the last few decades. Diabetes is a long-term medical condition marked by high blood glucose levels and abnormal protein and fat metabolism. When the pancreas is unable to create enough insulin or the cells are unable to use the insulin that is produced efficiently, blood glucose levels rise because the glucose cannot be digested in the cells. Diabetes comes in three main forms: (1) Type 1, in which insulin is not produced by the pancreas. gestational diabetes, which develops during pregnancy and can result in complications during pregnancy and at birth, increasing the risk of type 2 diabetes in the mother and obesity in the offspring; and (d) type 2, in which the body cells are resistant to the action of the insulin that is being produced and the production of insulin gradually decreases over time.

Diabetes Complication :	**Symptoms Of Diabetes :**
Diabetic Foot	Frequent Urination
Glaucoma	Weight loss
Cataracts	Blurred Vision
Heart Attack	Tingling In Hands

Bakery industry is the one of the largest food industries in India with an annual turnover about 3000 billion. As they lead busy lives, people these days demand ready-to-cook meals that taste good, are nourishing, easy to create, require less time to cook, and have a long shelf life. Therefore, all of them attractive in this research. We make an effort to provide functionality to the cookie. Every age group enjoys eating produced snacks, such as cookies. It is produced worldwide and is more commonly available. These days, consumers are searching for two essential food attributes: the first pertains to the dish's conventional nutritional value, and the second is the likelihood of additional health benefits from regular consumption. Due to improvements in healthy lifestyle choices, foods with high nutrition have gained a lot of attention recently on a global scale. Cookies are widely known and eaten in underdeveloped nations. Traditionally, wheat flour is used to make cookies. The word "Cookie"

is derived from the Dutch word "Koekie," which means "little cake." Similar to cakes, cookies are chemically leavened using baking soda and powder. Conversely, cookies have a correspondingly higher sugar and shortening agent content and a lower water content. Nutritional enhancement is receiving attention because it is a trend among consumers, a government-mandated policy, and changing demographics. These factors are making the market aware of the need for nutrient dense food items. One approach to lessen the need for nutrient-dense foods mostly baked goods is to incorporate protein. It is common knowledge that bakery products have nutritional implications**.**

Types of Cookies: .

1. Bar-shaped cookies:
2. Drop Cookies:
3. Filled Cookies:
4. Moulded Cookies:
5. Fried Cookies:
6. No Bake Cookies:
7. Pressed Cookies:
8. Refrigerator Cookies or Box Cookies:
9. Rolled Cookies:
10. Sandwich Cookies:

Aegle marmelos:

Fig 7: Aegle marmelos

➢ **Taxonomical Classification**:

- Kingdom: Plantae
- Order: Sapindales
- Family: Rutaceae
- Genus: Aegle
- Species: *A.marmelos*

Aegle marmelos also known as Bael leaves (from the tree *Aegle marmelos*), is a traditional medicinal plant widely used in Ayurvedic medicine. The leaves of the Bel tree have been recognized for their therapeutic properties, particularly in the management of diabetes. Rich in antioxidants, essential oils, and bioactive compounds like tannins and flavonoids, Bel Patra is believed to help regulate blood sugar levels by improving insulin sensitivity and reducing oxidative stress.

➢ **Cultivation of *Aegle marmelos*:**

Bael grows well in subtropical and tropical climates It can be propagated from seeds or cuttings.
Seeds: Common but slow method. Germination takes 10–15 days
Budding and grafting are preferred for uniform quality and early fruiting.
Leaves can be harvested throughout the year, but the medicinal quality is highest during the early morning hours.
Planting is done during the monsoon or early spring season.

➢ **Collection of *Aegle marmelos:***

Leaves are handpicked carefully to avoid damage to the tree. Only mature, healthy leaves (preferably three-lobed) are collected. Pods are harvested when young and tender, usually around 60-90 days after planting.
Collected leaves are washed gently with clean water to remove dust and insects.
Leaves should be free from disease, pests, and mechanical damage.
Dried leaves are stored in airtight containers away from moisture and sunlight to retain their efficacy.
Aegle marmelos is a well-known herbal remedy in Ayurvedic medicine, particularly valued for its

potential benefits in managing diabetes mellitus. Here's detailed information about how it helps:

➢ **Active Compounds**

Bael Patra contains several bioactive components with antidiabetic properties, including:

- Tannins
- Flavonoids
- Coumarins
- Alkaloids
- Essential oils

These compounds have antioxidant, anti-inflammatory, and hypoglycaemic effects, which are beneficial for blood sugar control.

➢ **Mechanism of Action in Diabetes**

i. Improves Insulin Sensitivity: Helps body cells respond better to insulin.
ii. Stimulates Insulin Secretion: Encourages the pancreas to produce more insulin naturally.
iii. Reduces Oxidative Stress: Protects pancreatic beta cells from damage caused by free radicals.
iv. Slows Glucose Absorption: Helps regulate the rate at which glucose enters the bloodstream after meals.

➢ **Forms of Use**

i. Fresh Juice: Juice from crushed fresh leaves, taken in the morning on an empty stomach.
ii. Powdered Leaves: Dried leaves ground into powder, consumed with warm water.
iii. Capsules/Extracts: Available in Ayurvedic stores as supplements.

➢ **Scientific Support**

Several animals and limited human studies support the antidiabetic effect of Bael leaves. They have shown:

i. Decreased blood glucose levels
ii. Improved lipid profile
iii. Enhanced antioxidant enzyme activity

➢ **Precautions**

Should be used under medical supervision, especially if the person is on insulin or oral hypoglycaemic drugs .Overuse may lead to hypoglycaemia (low blood sugar).

Annona squamosa

Fig 8: Annona squamosa

➢ **Taxonomical Classification**:

- Kingdom: Plantae
- Order: Magnoli ales
- Family: Annonaceae
- Genus: Annona
- Species: Annona squamosa

Custard apple, scientifically known as *Annona squamosa*, is a tropical fruit-bearing tree whose leaves are gaining recognition in traditional and modern medicine for their potential role in managing diabetes. The leaves are rich in bioactive compounds such as flavonoids, phenols, tannins, and alkaloids, which contribute to their antidiabetic effects.

➢ **Cultivation of *Annona squamosa*:**

Thrives in warm, dry tropical and subtropical climates. Sensitive to frost but drought-tolerant.

Commonly propagated by seeds, though it takes longer to bear fruit.
Typically planted at a distance of 4–5 meters between trees.
Best planted during the rainy season (June–August).
Mature trees are drought-resistant and need watering only during long dry spells.
Pruning is typically done after harvest to encourage new shoot formation.
Leaf spot, powdery mildew — managed through neem-based sprays or mild fungicides.

➢ **Collection of *Annona squamosa*:**

Leaves can be collected throughout the year, but avoid collection during the rainy season to prevent fungal contamination.
Choose fully grown, healthy green leaves.
Leaves are plucked gently by hand or with small scissors to avoid tearing or damaging the branch.
Rinse gently with clean water to remove dirt or insects.
Store dried leaves in airtight containers, away from moisture, heat, and light.
Custard apple is a tropical plant known for its sweet fruit. Beyond the fruit, the leaves of Annona squamosa have gained interest in traditional medicine for their therapeutic potential, especially in treating diabetes mellitus.

➢ **Phytochemical Composition**

Custard apple leaves are rich in several bioactive compounds, including:

- Flavonoids: Powerful antioxidants that reduce oxidative stress, a major contributor to insulin resistance.
- Tannins: Known for their anti-inflammatory and astringent properties.
- Saponins: May help lower blood glucose and cholesterol.
- Alkaloids and Glycosides: Often associated with anti-diabetic effects in herbal medicines.

➢ **Mechanisms of Action in Diabetes Management**

Research suggests that custard apple leaves may help manage diabetes through several mechanisms:

1. Insulin Sensitization
   The leaves may improve the body's response to insulin, helping glucose enter cells more effectively.
2. Inhibition of Carbohydrate-Digesting Enzymes
   Compounds in the leaves may inhibit enzymes like alpha-amylase and alpha-glucosidase, slowing the breakdown and absorption of sugar from food.
3. Reduction in Oxidative Stress
   Diabetes often leads to oxidative damage. The antioxidants in custard apple leaves can reduce this stress and protect pancreatic beta-cells.
4. Improved Lipid Profile
   Some studies suggest that the leaves may help reduce LDL (bad) cholesterol and increase HDL (good) cholesterol, which is beneficial in diabetic patient.

➢ **Whole Wheat:**

Fig 6: wheat flour

Due to its many health benefits, wheat is the most widely available cereal in the world and has

become much more popular in recent years. Wheat provides an enormous amount of energy through the bran, kernel, and endosperm, among other parts of the grain. More often than any other cereal, wheat is the main grain used to make bread. The gluten protein assembles the bread mixture and gives it the ability to retain gas. Approximately 20% of the world's calories come from wheat, which is a staple grain in many countries. The majority of crackers, breads, rolls, biscuits, cakes, cookies, macaroni, puddings, doughnuts, spaghetti, and many more prepared hot and cold breakfast meal variations use wheat as their main ingredient. Zinc, mineral salts, magnesium, chlorine, iodine, potassium, sulphur, vitamin B, arsenic, silicon, manganese, copper, calcium, and vitamin E are all abundant in wheat. The main source of Diabetes in a typical diet is wheat. It is frequently used as a cultural ground or root of nourishment because of its profusion of nutrients. Grains of wheat are ground into a powder called wheat flour, which is consumed by humans.

➢ **Ragi flour:-**

Fig 9: Ragi Flour

Ragi flour, also known as finger millet flour, is considered beneficial for diabetic patients due to several key properties:

1. Low Glycaemic Index (GI)
   Ragi has a low to moderate glycaemic index, which means it causes a slower rise in blood sugar levels compared to high-GI foods. This helps in better blood glucose control for people with diabetes.
2. Rich in Dietary Fiber
   Ragi is high in soluble and insoluble fibre, which aids in:
   I. Slowing digestion and glucose absorption
   II. Promoting satiety (feeling full longer)
   III. Improving bowel movements
3. High in Polyphenols and Antioxidants
   These compounds help in:
   i. Reducing oxidative stress (which is higher in diabetics)
   ii. Enhancing insulin sensitivity
4. Gluten-Free
   Ragi is naturally gluten-free, making it a good option for diabetics with gluten sensitivity or celiac disease.
5. Nutritional Profile
   Ragi is rich in:
   i. Calcium (good for bone health)
   ii. Iron (helps with anaemia)
   iii. Amino acids like methionine (supports metabolism)

MATERIALS AND METHODS

❖ Materials: *Aegle marmelos* leaves powder, *Annona squamosa* leaves powder, Ghee, Jaggery, Coco powder, Baking Powder, Wheat flour, Ragi Flour, Milk powder

❖ Instruments: Sieves, Grinder, Oven, Stability Chamber

❖ **Method:**

➢ *Aegle marmelos*

- Collection of Leaves: The leaves of *Aegle marmelos* was collected from local market.
- Preparation of *Aegle marmelos* leaves powder:
  The leaves were washed thoroughly under running water. Then it was dried for 6-7 days in sunlight. The dried sample were grinded properly using mortar and pestle and then grounded using an electric grinder to achieve

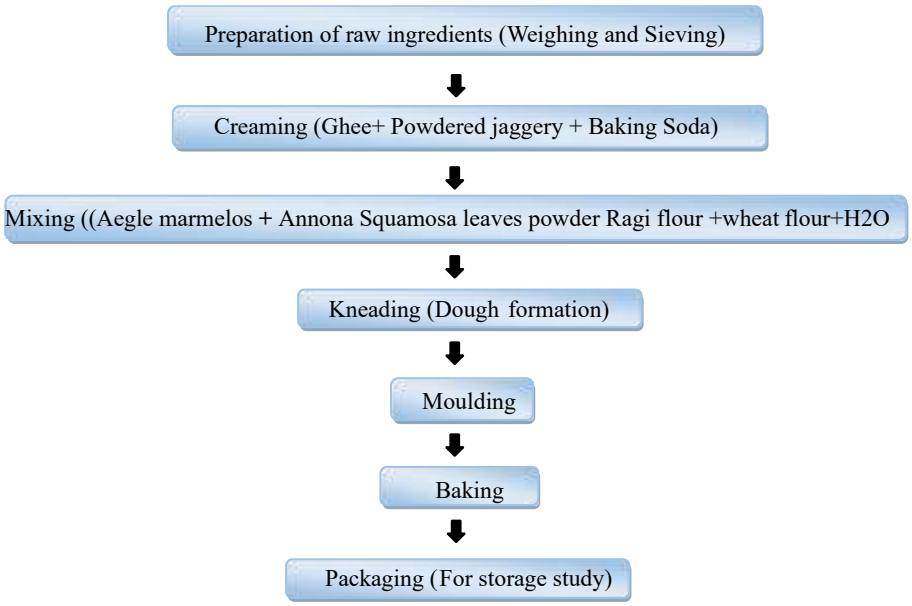
desired size. The powder of the leaves was stored in air tight container.

➢ *Annona squamosa*

- Collection of Leaves: The leaves of *Annona squamosa* was collected from local market
- Preparation of Annona squamosa leaves powder:

The leaves were washed thoroughly under running water. Then it was dried for 6-7 days in sunlight. The dried sample were grinded properly using mortar and pestle and then grounded using an electric grinder to achieve desired size. The powder of the leaves was stored in air tight container

- Procedure for preparation of cookies:



EVALUATION:

Phytochemical screening:

Test for alkaloids-:

a. Dragendorff's test:

Addition of 1 mL of Dragendorff's reagent to 2 mL of extract, a reddish brown precipitate was formed, indicating the presence of alkaloids.

b. Mayers test:

2 ml of concentrated HCl was added to 2 ml of the respective plant extract samples followed by an addition of few drops of Mayer's reagent. Pale yellow precipitate was formed, indicates presence of alkaloid.

c. Hager's test:

Addition of a few drops of the hagers reagent to plant extracts and appeared a yellow-coloured precipitate that indicates the presence of alkaloids. Hager's reagent is saturated solution of picric acid.

d. Wagner's test:

Few drops of wagners solution were added to the 2mL of filtrate; a brown coloured precipitate indicates the presence of alkaloids.

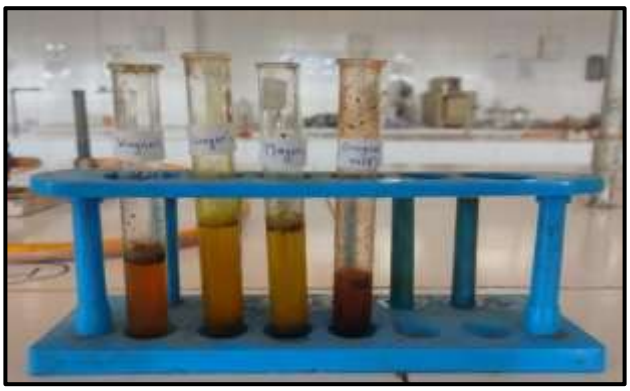


Fig 4: Alkaloid Tests Herbal Drugs

Test for flavonoids-:

a. Lead sub-acetate test:

Take 2mL of filtrate, in which add 2 drops of lead sub-acetate solution, yellowish precipitate can observe which indicates that presence of flavonoids.

b. Shinoda test:

Take alcoholic solution of powdered drug, add 2 mL drops of HCL to it, an orange/red colour can be formed it indicates presence of flavonoids.

Fig 5: Flavonoids Tests for Herbal Drugs

III. Test for tannins-:

a . Ferric chloride test:

Addition of 1% fecl3 solution to the alcoholic extract of powdered drug, brownish green colour was observed it indicates that presence of tannins.

b. Saponin test:

Specific quantity of water added to the test tube which contained powdered drug in it. Shake for 15 minutes, and allow to stand. After 5-10 minutes foam was observed.

Test for glycosides-:

a. Borntrager's test:

To 1 gm of drug add 5–10 ml of dilute HCl boil on water bath for 10 min and filter. Filtrate was extracted with CCl4/ benzene and add equal amount of ammonia solution to filtrate and shake. Formation of pink or red colour in ammoniacal layer due to presence of anthraquinone moiety.

Test for carbohydrates-:

b. Molisch's test:

Take 2mL of sample in dry test tube. Take 2 mL of distilled water in another test tubes as control. Add 2-3 drops of Molisch's reagent to the solution. Gently pipette 1mL conc. H2SO4 alongside of test tube so that two distinct layers are formed. Observe colour change at the junction of two layers. Appearance of violet colour indicates that presence of carbohydrates.

Table no. 4: Formulation table

Ingredients	T_0	T1	T2	T3	T4	T5	T6
Ragi Flour	100 gm	75 gm	75 gm	50 gm	50 gm	50 gm	50 gm
Wheat Flour	___	___	___	25 gm	25 gm	25 gm	25gm
Aegle marmelos leaves powder	___	5 gm	___	5gm	___	3 gm	2 gm
Annona squamosa leaves powder	___	___	5 gm	___	5 gm	2 gm	3 gm
Ghee	50 gm	50 gm	50 gm	50 gm	50 gm	50 gm	50 gm
Jaggery	25 gm	25 gm	25 gm	25 gm	25 gm	25 gm	25 gm
Milk Powder	5 gm	5 gm	5 gm	5 gm	5 gm	5 gm	5 gm
Baking Powder	1 gm	1 gm	1 gm	1 gm	1 gm	1 gm	1 gm

Fig 14: Batch T0

Fig 15: Batch T1

Fig 15: Batch T2

Fig 16: Batch T3

Fig 17: Batch T4

Fig 18: Batch T5

Fig 19: Batch T_6

➢ **Physiochemical Properties Of Cookies**

- **Ash Value -:**

The following method was used to estimate the prepared cookies' total ash content . As per the protocol, one gram of the material was placed in a crucible covered with tar and burned on a Bunsen burner until all of the carbon was burned. After cooling, the sample was weighed, and the process was repeated until the weight remained constant. The total ash value was then determined using the following equation: Value of total ash: 100(Z-X) / Y where X is the weight of the empty dish, Y is the weight of the sample that was obtained, and crucible with sample after full burn.

- **Moisture Content-:**

The technique outlined in the Chemical Analysis of Food [10] was used to assess the moisture content. As stated in the process, samples of cookies were precisely weighed in a moisture dish, heated to 105°C for two hours, cooled in desiccators, and then weighed again. After 30 minutes of heating, the process was repeated, cooled, and weighed. This process continued until there was less than a 0.001 gram discrepancy between two subsequent weigh-ins. The following equation was used to determine the test sample's moisture content: The moisture percentage is calculated as (W1-W2) x 100/W1-W, where W is the weight of the moisture dish containing the sample before drying, W_2 is the weight of the moisture dish containing the sample after drying, and W is the weight of the moisture dish**.**

- **Fat Content-:**

Content of fat: In accordance with the protocol [10], two grams of the sample were stored in a Soxhlet apparatus with a 1:1 mixture of diethyl alcohol and petroleum ether for six hours. The ether was then extracted by distillation, and the sample was dried in a hot air oven at 110 degrees Celsius and Cand before being cooled in a desiccator. The dried sample was taken and weighed once again. Diethyl ether was added to the left residue, and the process was repeated until the weight remained constant at 110 ± 1°C.
percentage of fat content = (M1-M2) x 100/sample weight where M1 is the round-bottom flask's weight with fat, and M2 is the flask's weight.

- **Protein estimation-:**

Estimation of proteins: Protein estimation was carried out using the DGHS Manual's recommended methodology [36]. Three grams of catalyst (K2SO4+CuSO4) was added to four test tubes containing 200–300 mg of cookie powder, in accordance with the procedure. Each tube received 10 millilitres of pure H2SO, which was digested for three to four hours. Following digestion, these samples were distilled using 40% sodium hydroxide, potassium permanganate, and boric acid before being acid-titrated. The ammonia was neutralized by this titration, and the following formula was used to get the protein percentage.
Protein content = Ammonia% x 6.25 Ammonia% = 14.01 x Reading-Blank x 100 × Normality / sample weight × 1000

- **Sensory Analysis-:**

64 participants in all took part in the study, which used a 9-point hedonic scale to evaluate sensory

aspects such flavour, scent, taste, look, and Odor. As the product was introduced and the questions were conveyed to the volunteers, the taste panellists were given questionnaires and mouthwash. Microsoft Excel was used to evaluate the collected data by age group.

RESULT AND DISSCUSION-:

- Objectives Defined: Objectives for the sensory evaluation were outlined, focusing on taste, texture, aroma, and overall acceptability.
- 20 participants were selected among them 10 were staff members and remaining were students.
- 20 observations were recorded using integrated numerical scale.

The following scale was used.

Table no. 1.2: Scale for survey Result And Discussion

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

Table no.1.3 : Chemical and physiochemical parameter

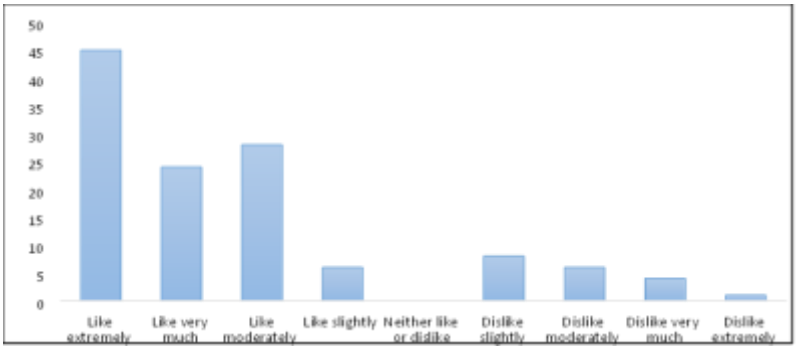
Chemical and physiochemical properties	Results
Ash Content	6.80%
Moisture Content	7.80%
Alkaloid	present
Flavonoid	present
Water extraction	5.35%
Fat content	12.50%
Protein content	11.65%
Tannins	Present
Total Energy	414.9874Kcal

By above mentioned Table 1 of results shown, those Cookies were spanking in nutritional values with controlled fat pod carbohydrate and high rich in protein content which have made it acceptable among the health-conscious exhibit, growing people and case of malnutrition. Comparative studies of different parameters of sensory evaluation exhibited that use of Aegle marmelos , Annona squamosa leaves as an active ingredient has given an appetizing and flavouring effect. Selected composition of cookies has made it acceptable around 90-96% that will give us a hope to convert this formulation into large scale production. In terms of physiochemical properties, nutrition value, sensory evaluation and comparison with other marketed product were inacceptable.

➢ **Survey on evaluation of cookies-:**

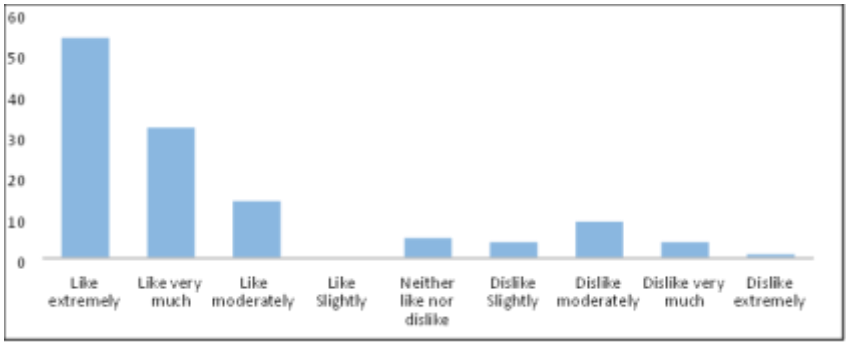
- **Taste**

One important sensory evaluation metric is taste. Even when the product is compelling and has a lot of energy, it is unlikely to be accepted if it lacks moral taste. According to the survey, the average score for the 18–40 age range was between 67 and 70% because of the use of *Aegle Marmelos* and *Annona Squamosa* leaves.



- **Flavour -:**

A key component of taste, flavour is essential to the acceptance of any food ingredient. All of the sensory evaluation volunteers thought the flavour of *Aegle Marmelos* and *Annona Squamosa* leaves to be very pleasing because their aroma served as an appetizer. Excel scores ranged from 68 to 70%.



Acceptance of Flavour

CONCLUSION

In conclusion, the incorporation of *Annona squamosa* (custard apple) and *Aegle marmelos* (Bael) leaves into cookie formulations presents a promising approach to developing functional foods aimed at glycaemic control. Both plant leaves are rich in bioactive compounds—such as flavonoids, alkaloids, phenolics, and tannins—which exhibit well-documented antidiabetic, antioxidant, and anti-inflammatory properties. The formulated cookies not only serve as a convenient and palatable option for diabetic individuals but also demonstrate potential in:

Reducing postprandial glucose levels through enhanced insulin sensitivity and glucose uptake.

Providing antioxidant protection, thereby reducing oxidative stress, a key factor in diabetic complications.

Maintaining sensory acceptability, especially when appropriate levels of leaf powder are used in combination with whole grain flours and natural sweeteners.

In summary, the use of *Annona squamosa* and *Aegle marmelos* leaves in cookie formulation supports the development of plant-based, nutraceutical-enriched functional foods. These cookies may serve as effective dietary supplements for the management of Type 2 diabetes when consumed as part of a balanced diet. However, further clinical studies are recommended to validate their long-term efficacy and safety in human populations.

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