

# Development and Evaluation of a Low-Fat Plant-Based Emulsion Mimicking Mayonnaise Using Hibiscus Leaf Hydrocolloids

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**Abstract:** *The present research aimed to develop and optimize a low-fat, plant-based functional emulsion using aqueous hibiscus leaf mucilage as a natural stabilizing and structuring agent. The study explored the potential of hibiscus leaf mucilage, in combination with green pea paste and corn starch, to form a stable oil-in-water emulsion with reduced reliance on conventional fat-based emulsifiers. Natural spices, acidulants, and a minimal amount of Sunflower oil were incorporated to achieve desirable texture, spreadability, and sensory acceptability. The functional objective of the study was to utilize the inherent polysaccharide-rich and fibre-containing properties of hibiscus leaves to enhance the nutritional and technological value of the emulsion. The developed formulation demonstrates the feasibility of using underutilized leafy plant resources and natural hydrocolloids in the creation of clean-label, vegan, and low-fat functional spreads, thereby contributing to sustainable and health-oriented food product development.*

**Keywords:** Hibiscus leaf mucilage, Plant-based emulsion, Functional food, Low-fat spread, Natural hydrocolloids, Vegan formulation, Clean-label ingredients, Dietary fibre enrichment, Emulsion stability

## I. INTRODUCTION

The growing interest in plant-based and functional foods has led to increased research on alternatives to conventional high-fat emulsified products. Concerns related to excessive fat consumption, along with the demand for vegan and clean-label foods, have encouraged the development of low-fat, plant-derived emulsion systems using natural ingredients.

Emulsions require effective stabilizing agents to maintain uniformity and prevent phase separation. Traditional emulsified spreads often rely on high oil content and animal-based emulsifiers, which increase caloric value and limit suitability for health-conscious and vegan consumers. As a result, plant-based hydrocolloids and proteins are being explored as natural substitutes to improve emulsion stability while reducing fat levels. Hibiscus leaves are a rich source of mucilage, a polysaccharide with strong water-holding and viscosity-enhancing properties. When dispersed in water, hibiscus leaf mucilage forms a thick matrix that can function as a natural stabilizer in emulsion-based food systems. The incorporation of green pea paste and corn starch can further enhance texture and structural stability, while natural spices and acidulants contribute to sensory quality. The present study focuses on the development and optimization of a low-fat functional plant-based emulsion using aqueous hibiscus leaf mucilage as the primary base, aiming to demonstrate its potential as a sustainable and vegan-friendly alternative to conventional emulsified spreads.

## II. MATERIALS AND METHODS

### A. Procurement of Raw Materials

Fresh hibiscus leaves were procured from local sources to ensure freshness and suitability for food applications. The leaves were selected based on uniform size, green color, and absence of physical damage or microbial spoilage. Green peas used for paste preparation were obtained from the local market and were free from visible defects. Corn starch, mustard powder, black pepper, garlic, sugar, salt, and lemon juice were purchased from certified food-grade retail outlets. Refined edible sunflower oil was used for emulsion formation.



### **B. Preparation of Green Pea paste**

Fresh green peas were washed thoroughly with potable water to remove surface impurities. The peas were soaked for 12 hours until it softened. After that, the cooked peas were blended using a mixer grinder to obtain a smooth pea milk. Then the pea milk is heated for 5 minutes for a thick paste like consistency. The prepared green pea paste was used immediately for formulation to ensure freshness and functional performance.

Figure 1 shows the prepared green pea milk

Figure 2 shows the green pea paste used in the formulation



Fig 1 Green pea milk



Fig 2 Green pea paste

### **C. Preparation of Aqueous Hibiscus Leaf Mucilage**

Fresh hibiscus leaves were thoroughly washed with clean water to remove dirt and foreign matter. The cleaned leaves were soaked in water for 12 hours at room temperature to facilitate mucilage release. The soaked leaves were then blended to obtain an aqueous dispersion. The resulting viscous mucilage-rich dispersion was kept.

Figure 3 shows the aqueous hibiscus leaf mucilage obtained after extraction.

Figure 4 shows the base (mucilage+pea paste+corn starch)



Fig 3 Hibiscus Leaf mucilage



Fig 4 Base(Mucilage+Pea paste+corn starch)

### **D. Formulation & Preparation of Hibiscus Whip (Low-Fat Plant-Based Emulsion)**

The different formulations of the plant-based emulsion used in the experimental trials are summarized in Table 1.



Table 1. Formulation of Hibiscus Whip for Various Trials

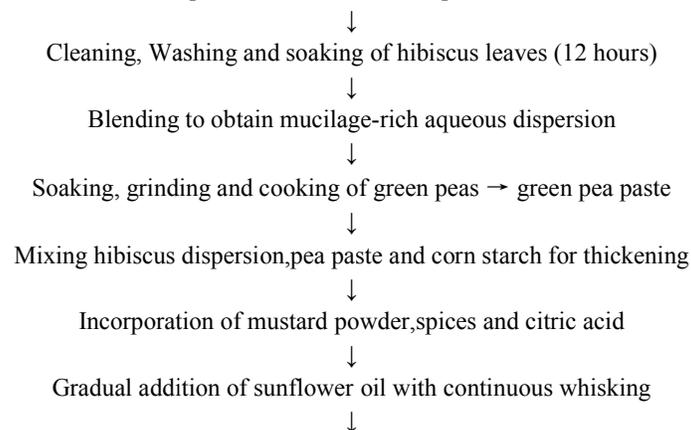
| Raw material                 | Control | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 |
|------------------------------|---------|---------|---------|---------|---------|---------|
| Hibiscus leaf dispersion (g) | 60.63   | 50      | 55.5    | 60.6    | 65.5    | 70 g    |
| Green pea paste (g)          | 15.50   | 15.50   | 15.5    | 15.5    | 15.5    | 15.5    |
| Corn starch(g)               | 6.20    | 5 g     | 5.5     | 6 g     | 6.5g    | 7 g     |
| Lemon juice (ml)             | 1.5     | 0.5     | 1 ml    | 1.5 ml  | 2 ml    | 2.5ml   |
| Salt (g)                     | 1.2     | 1.2     | 1.2     | 1.2     | 1.2     | 1.2     |
| Sugar (g)                    | 1.5     | 0.5     | 1 g     | 1.5     | 2 g     | 2.5     |
| Pepper (g)                   | 1.5     | 0.5     | 1 g     | 1.5     | 2 g     | 2.5     |
| Garlic (g)                   | 3.0     | 1 g     | 2 g     | 3 g     | 4 g     | 5 g     |
| Mustard powder (g)           | 1.0     | 0.5     | 0.8     | 1 g     | 1.5     | 2 g □   |
| Refined sunflower oil (ml)   | 8.50    | 8.5     | 8.5     | 8.5     | 8.6     | 8.5     |

**Notes:**

Quantities are in grams (g) or milliliters (ml).

Trial 3 is the optimized formulation, giving the best emulsion stability and texture.

Flowchart for Preparation of Hibiscus Whip Raw material selection



Mild heat treatment (1–2 min) to improve texture and stability



Formation of low-fat plant-based emulsion (Hibiscus Whip)

### HIBI WHIP



Fig 5 Final product



Fig 6 Final product weight

## III. RESULT AND DISCUSSION

### A. Evaluation of Physicochemical, Nutritional, and Functional Parameters

#### 1. pH

The pH of the product was determined in the laboratory using a digital pH meter. The instrument was calibrated using standard buffer solutions before use. The pH of the sample was found to be 4.18, indicating a slightly acidic nature. This acidic pH is suitable for mayonnaise-type products and helps in improving product stability and safety.

#### 2. Titratable Acidity

Titrateable acidity was determined in the laboratory by titrating a known quantity of sample against standard sodium hydroxide solution using phenolphthalein as an indicator. The endpoint was noted by the appearance of a light pink color. The titrateable acidity of the product was found to be 0.6%, which contributes to the characteristic taste and preservation of the product.

#### Moisture content

Moisture content of the sample was found to be 73.1%. The analysis was carried out at a nearby laboratory using standard analytical procedures. High moisture content contributes to the soft texture and spreadable nature of the product.

#### Ash content

Ash content was reported as 9.16% and was analyzed at a nearby laboratory using standard methods. Ash content indicates the total mineral matter present in the product, which may be attributed to the plant-based ingredients used in the formulation.

#### Fat content

The fat content of the product was found to be 0.31%, as analyzed in a nearby laboratory. The very low fat value shows that the product is a low-fat alternative when compared to conventional mayonnaise.

#### Protein content

Protein content was reported as 0.56%. Protein analysis was carried out in a nearby laboratory using standard methods. The low protein content may be due to the absence of egg or other protein-rich ingredients.



**Carbohydrate content**

Carbohydrate content was found to be 13.0% and was calculated at a nearby laboratory using standard procedures. Carbohydrates contribute to both energy value and functional properties such as thickness and stability.

**Energy value**

The energy value of the product was reported as 72.46 kcal per 100 g. Energy was calculated based on proximate composition by the nearby laboratory. The low energy value makes the product suitable for calorie-conscious consumers.

**Crude Fiber**

Crude fiber content was found to be 6.09%, as analyzed by the nearby laboratory. The presence of fiber enhances the nutritional and functional quality of the product.

Emulsion stability analysis was conducted at a nearby laboratory, and the sample passed the emulsion stability test. This indicates that the formulation was able to maintain a stable emulsion without phase separation.

**Viscosity**

Viscosity of the product was measured at the nearby laboratory and was found to be 2.10 cP. The viscosity value indicates a smooth consistency suitable for use as a spread or dip.

**Total plate count (TPC)**

Total plate count was reported as  $3 \times 10^4$  CFU/g. Microbial analysis was carried out at the nearby laboratory using standard microbiological techniques. The results indicate acceptable microbial quality for a freshly prepared product.

Fig 7 Physicochemical, Nutritional, and Functional Parameters

| Parameter               | Result          |
|-------------------------|-----------------|
| pH                      | 4.18            |
| Titrateable acidity (%) | 0.6             |
| Moisture (%)            | 73.1            |
| Ash                     | 9.16            |
| Fat (%)                 | 0.31            |
| Protein                 | 0.56            |
| Carbohydrate            | 13.0            |
| Energy                  | 72.46           |
| Crude fiber             | 6.09            |
| Emulsion stability      | Passes test     |
| Viscosity               | 2.10 cP         |
| TPC                     | $3 \times 10^4$ |



### E. Sensory Evaluation

The sensory evaluation of the developed Hibiscus Whip was conducted by a panel of five members, who assessed the product based on taste, texture, aroma, and appearance. The panelists reported that the spread had a smooth and spreadable consistency, attributable to the hydrocolloids present in the hibiscus leaf dispersion. The mild acidity (pH 4.18) provided a pleasant tangy taste, while the natural color from hibiscus leaves gave the spread an attractive appearance. The aroma was subtle, with no overpowering plant notes, making it acceptable for consumption. Overall, the product received favorable scores for texture and appearance, indicating that the use of plant hydrocolloids effectively enhanced the functional and sensory properties of the low-fat emulsion. These results suggest that the Hibiscus Whip can be considered organoleptically acceptable as a low-fat functional plant-based Emulsion like spread.

| Parameter             | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Average score |
|-----------------------|---------|---------|---------|---------|---------|---------------|
| Taste                 | 3.8     | 3.6     | 4.2     | 3.9     | 3.7     | 3.84          |
| Texture               | 3.9     | 3.7     | 4.3     | 3.8     | 3.8     | 3.90          |
| Aroma                 | 3.7     | 3.5     | 4.1     | 3.6     | 3.6     | 3.70          |
| Appearance/color      | 3.8     | 3.6     | 4.2     | 3.7     | 3.7     | 3.80          |
| Overall Acceptability | 3.8     | 3.6     | 4.2     | 3.7     | 3.7     | 3.80          |

### IV. CONCLUSION

The present study successfully demonstrated the development of a low-fat, plant-based functional emulsion (Hibiscus Whip) using hibiscus leaf hydrocolloids. The product showed acceptable physicochemical, nutritional, functional, and sensory properties with very low fat and energy content. Although it is not a traditional mayonnaise, the formulation achieved a mayonnaise-like taste and spreadability while offering health-oriented benefits. The study highlights the potential of plant hydrocolloids as natural stabilizers in the development of low-fat functional spreads.

### F. Need of the study

The increasing demand for low-fat, plant-based, and clean-label foods has created the need for alternatives to conventional high-fat emulsified products such as mayonnaise. This study was undertaken to explore the potential of hibiscus leaves as a natural source of plant hydrocolloids for developing a functional emulsion with reduced fat and calorie content. The work also aimed to utilize underexploited plant resources and promote healthier food formulations using natural ingredients.

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