

# Development of Apple–Beetroot–Carrot–Amla Functional Nutraceutical Gel Using Natural Hydrocolloids

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**Abstract** — *The increasing demand for natural, health-promoting, and minimally processed foods has accelerated the development of fruit-based nutraceutical formulations. In this study, a functional nutraceutical gel was developed using equal proportions of apple, beetroot, carrot, and amla, supplemented with lemon juice for enhanced antioxidant stability and flavor. The extracted juice was concentrated using jaggery as a natural sweetener and structured using xanthan gum and gelatin to obtain a stable gel matrix. The prepared gel combines the nutritional benefits of multiple fruits, including vitamin C, beta-carotene, polyphenols, iron, and essential minerals. The use of natural ingredients without synthetic additives enhances the safety and consumer acceptability of the formulation. The developed gel exhibited desirable texture, uniform consistency, and potential health benefits such as improved immunity, antioxidant activity, and nutritional supplementation. This study demonstrates a simple, cost-effective, and sustainable approach for developing fruit-based functional gels with potential applications in nutraceutical, functional food, and health-supplement industries.*

**Index Terms** — **Functional food, Nutraceutical gel, Natural hydrocolloids, Fruit gel, Antioxidant, Plant-based gel.**

## I. INTRODUCTION

In recent years, there has been an increasing interest in functional foods and nutraceuticals due to growing awareness regarding health and nutrition. Functional foods not only provide basic nutrition but also offer additional health benefits, including improved immunity, prevention of chronic diseases, and enhanced metabolic function [1]. Natural fruit-based formulations have gained considerable attention due to their rich content of vitamins, minerals, antioxidants, and phytochemicals.

Apple, beetroot, carrot, and amla are widely recognized for their nutritional and therapeutic properties. Apple contains polyphenols and dietary fiber that support cardiovascular health. Beetroot is rich in nitrates and iron, which help improve blood circulation and hemoglobin levels. Carrot contains beta-carotene and antioxidants beneficial for vision and immune health [2]. Amla is one of the richest natural sources of vitamin C and possesses strong antioxidant properties.

Gel-based nutraceutical formulations offer several advantages, including easy consumption, improved stability, controlled release of nutrients, and enhanced shelf life. Hydrocolloids such as xanthan gum and gelatin are commonly used for gel formation. Xanthan gum provides viscosity and stability, whereas gelatin contributes to gel strength and elasticity [3].

This study aims to develop a natural functional gel using apple, beetroot, carrot, amla, and lemon juice, with jaggery as a natural sweetener and xanthan gum and gelatin as gelling agents.

## II. MATERIALS AND METHODS

### 2.1 Materials

Fresh fruits and other ingredients used for the preparation of functional nutraceutical gel included apple, beetroot, carrot, amla, and lemon. Jaggery powder was used as a natural sweetening agent. Xanthan gum and gelatin were used as natural hydrocolloids for gel formation. Distilled water was used for washing and cleaning purposes. All materials were procured from local markets and used without further purification.

## 2.2 Preparation of Fruit Extract

Fresh apple, beetroot, carrot, and amla were washed thoroughly using distilled water to remove dirt and impurities. Beetroot and carrot were peeled and cut into small pieces. Equal proportions (1:1 ratio) of apple, beetroot, carrot, and amla were taken. A small quantity of lemon juice was added to enhance flavor and prevent oxidation [4].

The mixture was blended using a high-speed blender until a homogeneous mixture was obtained.

## 2.3 Filtration and Pulp Removal

The blended mixture was filtered using muslin cloth to remove coarse particles and fibrous pulp. The filtered juice was collected in a clean container and measured for further processing.

## 2.4 Juice Concentration

The filtered juice was transferred into a clean pan (tawa) and heated at low to medium temperature. Jaggery powder was added gradually according to taste preference. The mixture was stirred continuously to prevent burning and ensure uniform mixing. Heating was continued until the mixture slightly thickened.

## 2.5 Gel Formation

After slight concentration, xanthan gum was added slowly with continuous stirring to prevent lump formation. Gelatin was then added to the mixture and stirred continuously until a homogeneous gel-forming solution was obtained. The mixture was maintained at low temperature during this process.

## 2.6 Moulding and Gel Setting

The prepared gel mixture was poured into moulds immediately while hot. The moulds were allowed to cool at room temperature and then refrigerated for 2–4 hours for complete gel formation [5].

## 2.7 Storage

The prepared gel samples were removed from moulds and stored in refrigerated conditions until further analysis

## III. RESULTS AND DISCUSSION

### 3.1 Physical Characteristics of the Developed Gel

The developed apple–beetroot–carrot–amla gel exhibited a smooth texture with uniform consistency and an appealing reddish-orange color. The characteristic color was primarily attributed to the presence of betalains from beetroot and  $\beta$ -carotene from carrot. The gel structure remained intact without visible phase separation, indicating successful gel formation using xanthan gum and gelatin as hydrocolloid agents. The addition of lemon juice helped preserve the color stability and minimized oxidation during processing [6].

The prepared gel demonstrated good moldability and retained shape after removal from molds. The gel consistency was firm yet soft enough for easy consumption, making it suitable for nutraceutical and functional food applications.

### 3.2 Effect of Hydrocolloids on Gel Formation

The incorporation of xanthan gum and gelatin played a crucial role in gel formation and stability. Xanthan gum enhanced viscosity and prevented phase separation by forming a stable hydrocolloid network. Gelatin contributed to gel firmness and elasticity by forming a three-dimensional protein network upon cooling [7,8].

The combined use of xanthan gum and gelatin resulted in improved gel strength, uniform texture, and enhanced structural integrity. The synergistic effect of these hydrocolloids improved the mechanical properties and stability of the developed gel [9].

### 3.3 Nutritional Contribution of Fruit Components

The selected fruits significantly contributed to the nutritional value of the developed gel.

Apple contains polyphenols and dietary fiber that provide antioxidant properties and support digestive health. Beetroot is rich in iron, nitrates, and betalains, which help improve blood circulation and hemoglobin levels. Carrot is a good source of  $\beta$ -carotene, which is converted into vitamin A and contributes to eye health and immune function. Amla is one of the richest sources of vitamin C and provides strong antioxidant

and anti-inflammatory properties [10,11]. Lemon juice enhances vitamin absorption and improves overall flavor.

The combination of these ingredients resulted in a nutritionally enriched gel with potential health-promoting properties.

### 3.4 Role of Jaggery as Natural Sweetener

Jaggery was used as a natural sweetening agent instead of refined sugar. In addition to sweetness, jaggery provides essential minerals such as iron, calcium, and potassium. The use of jaggery improved the nutritional profile of the gel and enhanced its suitability as a functional food product [9]. Furthermore, jaggery contributed to improved texture and viscosity during heating.

### 3.5 Gel Stability and Storage Behavior

The prepared gel samples were stored under refrigerated conditions to evaluate stability. The gel maintained its structural integrity and showed no visible syneresis or phase separation. The presence of xanthan gum improved water retention, while gelatin enhanced gel strength, resulting in improved stability during storage. The addition of lemon juice also contributed to improved shelf stability by lowering pH and reducing microbial growth potential [11-13].

### 3.6 Functional and Nutraceutical Potential

The developed fruit-based gel demonstrated potential as a nutraceutical and functional food product due to the presence of bioactive compounds, antioxidants, vitamins, and minerals. The gel formulation offers several health benefits, including:

- Antioxidant activity
- Immunity enhancement
- Iron supplementation
- Improved digestion
- Nutritional support

The use of natural ingredients without synthetic preservatives further enhances the safety and consumer acceptability of the developed product.

## IV. CONCLUSION

In the present study, a fruit-based functional nutraceutical gel was successfully developed using apple, beetroot, carrot, and amla in equal proportions, with lemon juice as a natural stabilizing agent. The formulation was prepared using jaggery as a natural sweetener and xanthan gum and gelatin as hydrocolloids for gel formation. The developed gel exhibited desirable physical characteristics, including smooth texture, uniform consistency, appealing color, and good structural stability. The incorporation of nutrient-rich fruits enhanced the nutritional profile of the gel by providing essential vitamins, minerals, antioxidants, and bioactive compounds. Beetroot contributed iron and betalains, carrot provided  $\beta$ -carotene, apple offered polyphenols, and amla supplied high vitamin C content, collectively improving the functional properties of the formulation. The use of jaggery further improved the nutritional value by providing essential minerals and eliminating the need for refined sugar. The developed gel demonstrated good stability under refrigerated conditions without phase separation, indicating effective gel formation by xanthan gum and gelatin. Additionally, the use of natural ingredients without synthetic additives enhances consumer safety and acceptability. The formulation also offers advantages such as ease of consumption, cost-effectiveness, and suitability for various age groups.

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