

## Introduction

The modern lifestyle has driven a significant shift towards convenience, leading to the rapid growth of the Ready-to-Eat (RTE) and Ready-to-Cook (RTC) markets. The expansion of the RTE/RTC market in India is driven by rapid urbanization, innovative product development, rising disposable incomes, and the growth of the e-commerce sector.

The Ministry of Food Processing Industries (MOFPI) provides further impetus for increased production of RTE and RTC products. Over the past decade, the RTE sector has evolved with an annual compound growth rate (CAGR) of 12%, while RTC foods have grown at a CAGR of 7%. By FY'30, the production of RTE/RTC foods in India is projected to reach approximately INR 9,600 crore (USD 1.15 billion) or 4.6 lakh metric tons (0.46 million tonnes), reflecting an anticipated CAGR of around 13%. (MOFPI, 2023). This growth is further supported by a strong regulatory framework, sustained research, and government initiatives to encourage inventions, entrepreneurship, and sectoral development. The need for Ready-to-Eat (RTE) and Ready-to-Cook (RTC) foods has increased, spurred by changing consumer preferences for convenient food options.

The major RTE and RTC products in the market promise convenience, minimal preparatory time, and ease on a day-to-day basis. There has been a transition from unhealthier packaged options to more need-based, consumer-friendly options catering to a range of individual preferences, such as gluten-free, high fiber, reduced use of trans fat, and salt. This trend aligns with the broader global movements towards healthy eating behaviour.

According to Sahu, et al. (2024), there is a spike in the instances of non-communicable illnesses and conditions, leading to 52% of the fatalities. Alterations in lifestyle, like unhealthy dietary habits and lack of exercise, led to the widespread occurrence of non-communicable diseases (NCDs) (Plasek et al., 2019). Anjana et al. (2023) have reported noteworthy prevalence estimates for diabetes and prediabetes in India, quantifying them at 101 million and 136 million, respectively. These figures represent a marked and concerning increase compared to earlier data (IDF Diabetes Atlas, 2021).

Integrating health and wellness into RTE and RTC foods has become essential due to rising consumer awareness about nutrition and preventive health. With increasing lifestyle-related disorders such as obesity and diabetes, there is an increasing interest in convenient foods that provide balanced nutrition without compromising on taste. Including functional ingredients, such as fiber, antioxidants, and plant-based proteins, can enhance the health benefits of these products. By integrating these ingredients, manufacturers can meet the growing demand for convenient, health-focused products, making RTE and RTC foods appealing to health-conscious consumers.

There has been a noteworthy increase in research attention on functional foods within food, health, and technological innovations. These foods present a promising avenue for improving human health and preventing diseases, harnessing the influential impact of our dietary choices (Essa et al., 2021).

Increasing evidence highlights the health benefits of a diet regimen high in fruits and vegetables, sparking greater interest in the bioactive phytonutrients that are significant in biological systems. Significant endeavours have been directed toward developing dietary fiber and resistant starch-rich supplementary products from fruits and vegetables. The emphasis has centred on innovating novel foods, ensuring that consumers can consistently avail themselves of the nutritive and health benefits of fruits and vegetables, irrespective of seasonal fluctuations. This strategy guarantees year-round accessibility to healthy food options.

Banana (*Musa* spp.), a persistently evergreen species from the Musaceae, is a major fruit crop in warm and humid climates worldwide because of its extensive variability in production, composition, and utility, primarily influenced by factors such as cultivar types, planting techniques, climate conditions, and nutrient availability. (Maseko et al., 2023). Bananas are the second most important crop in India, and Tamil Nadu is the hub of banana production in India (MOFPI, 2024), making accessibility to this ingredient easy and paving the way for more research into developing functional foods.

Bananas are wholesome, nutrient-rich fruits that serve as key sources of macronutrients, micronutrients, and phytonutrients (Afzal et al., 2022) with a delicious taste and are available perennially. Bananas are highly preferred as they are versatile, affordable, and rich in resistant starch, which supports gut health. Although unripe bananas are often

treated as common vegetables and consumed domestically in India, their potential as a significant prebiotic source remains largely untapped.

Prebiotics, including resistant starch, inulin, fructo-oligosaccharides, and galacto-oligosaccharides, significantly enhance the proliferation of beneficial microorganisms and foster the generation of favorable fermentation products. Bananas possess prebiotic properties as the major non-digestible carbohydrate components like resistant starch, cellulose, hemicelluloses, and lignin serve as a probiotic nutrient source. Consequently, the proliferation of probiotic bacteria suppresses the proliferation of pathogenic bacteria (Powthong et al., 2020), and this protective action extends beyond the gastrointestinal tract, positively influencing the central nervous, immune, and cardiovascular systems (Ashaolu et al., 2020).

Plant-based diets are rich in phytochemicals and support health through their antioxidant, anti-inflammatory, and anticarcinogenic effects. They are essential in preventing degenerative disorders and lowering the risk (Monjotin et al., 2022). Research findings indicate that unripe (green) banana flour contains significant quantities of resistant starch and oligosaccharides and exhibits antioxidant activity (Chang et al., 2022).

Resistant starch from banana flour emerges as a viable functional ingredient for food products. Its benefits in managing obesity, cardiovascular disease, diabetes, and colorectal cancer are attributed to its resistance to hydrolysis and limited digestion, which slows glucose absorption and promotes colonic short-chain fatty acid production (Dibakoane et al., 2022).

Resistant starch acts like dietary fiber in the body and lowers glycemic response. Guiding individuals to follow a low-GI diet by substituting high-GI foods with lower-GI alternatives is a beneficial approach for improving blood sugar regulation (Vlachos et al., 2020). The glycemic index and resistant starch are pivotal in understanding carbohydrate metabolism and their health implications. Resistant starch not only aids in glycemic control but also promotes satiety and weight management by enhancing feelings of fullness (Sardá et al., 2016). Foods with a low GI generally cause a slower, more gradual increase in blood sugar, a response that the presence of resistant starch can modulate. Incorporating resistant starch-rich foods, such as unripe bananas and legumes, can be an effective dietary strategy for managing blood sugar levels and supporting metabolic health.

Research has shown promising results regarding the health benefits of banana-based products. Tian et al. (2020) reported that banana powder fermented with select human gut microbiota positively influenced the composition of intestinal microflora. According to Fu et al. (2022), supplementing unripe plantain flour lowered insulin levels in obese rats and positively impacted gut microbiota. These findings highlight the potential of UBF in promoting gut health and metabolic balance.

The flesh and skin of bananas contain diverse phyto nutrients and bioactives (Borges et al., 2019). Bananas demonstrate a higher antioxidant potential, attributed to elevated levels of these bioactive constituents compared to many berries, herbs, and vegetables, and bananas exhibit cultivar-dependent variations in their phytosterol content (Arias et al., 2022).

Bananas' beneficial health effects are attributed to the bioactive substances, especially their phenolic constituents (Kritsi et al., 2023). Furthermore, bananas are known for their potential benefits in treating various health conditions, including supporting digestive health, protecting kidney function, enhancing muscle endurance, and alleviating muscle spasms and mood disorders (Christi et al., 2019).

Banana flour shows potential as an alternative to wheat flour in producing various bakery items, including bread, cookies, cakes, pasta, and more (Marta et al., 2022). The availability of bioactive compounds in high levels, especially the resistant starch found in unripe banana flour, and its incorporation in foods offer significant opportunities for product development, including gluten-free options (Khoozani et al., 2019).

Utilizing bananas for flour production can drive economic benefits, such as price appreciation and trade, while fostering food innovation (Salazar et al., 2021). The incomplete identification of cultivars suitable for flour production, and challenges in post-harvest operations and new product development present significant hurdles. Identifying appropriate varieties and the optimal maturity stage of unripe bananas is essential for expanding their use in both the food and industrial sectors (Maseko et al., 2023).

The utilization of unripe banana flour holds significance as a novel ingredient for producing functional foods (Khoza et al., 2021). Tapping into the benefits of banana processing and its by-products has the potential to yield nutritious foods enriched with bioactive compounds, showcasing antioxidant, antimicrobial, and antidiabetic properties

(Kumari et al., 2023) and contribute to the prebiotic component, which can positively influence gut health.

The adoption and utilization of high-yielding banana cultivars, particularly those belonging to the *Musa acuminata* AAA subgroups, have restricted the utilization of native and less popular varieties (Maseko et al., 2023).

*Musa paradisiaca* cultivar Peyan (regional name) with an ABB genome, grown in Tamil Nadu and Kerala, is known for its short, ridged fruits with a broad base and slightly tapered apex. Peyan cultivar is recognized for its therapeutic benefits and is a viable backyard cultivar in traditional banana-growing zones (Uma et al., 2005).

The *Musa paradisiaca* cultivar Monthan (regional name), with an ABB genome, is a popular cooking banana in India. The Monthan banana cultivar is one of the most widely cultivated varieties on a large commercial scale in the Cauvery delta region, Tamil Nadu, India. This prevalence can be attributed to the region's topography, soil type, crop characteristics, environmental conditions, regional preferences, and domestic market value (Manonmani et al., 2023). Its fruits are mildly curved, robust, distinctly five-sided, with pronounced ridges. They feature a broad base that narrows into a long, angular pedicel and end in a wide apex with a knob-like beak (Venkataramani, 1946).

Banana flours derived from various cultivars exhibit distinct characteristics (Kumar et al., 2019), highlighting the need to investigate their potential for industrial applications. Hence, the study was carried out with a focus on specific cultivars of *Musa paradisiaca* Peyan and Monthan, adding depth to the investigation, considering the potential variations in nutritional content and functional properties among different banana varieties. This study seeks to expand the existing knowledge on the assessment of unripe banana flour quality and its application in food product development, emphasizing its prebiotic attributes and glycemic impact in the context of RTE and RTC formulations.

### **Research Gap**

Despite the cultural and economic importance of *Musa* cultivars Peyan (ABB) and Monthan (ABB), there is a notable lack of research addressing their starch characteristics and nutritional and functional properties. Current literature primarily focuses on agricultural practices and propagation, as shown by a Google Scholar search yielding 608 results for

'Peyan,' with only a few studies directly investigating the food and nutritional value of 'Monthan'. Research databases rarely provide details on the specific cultivar type and ripening stage, leading to a limited understanding of the nutritional variations among different banana cultivars and maturity levels.

Considering that the properties of banana flours vary significantly by variety, a comprehensive analysis of the starch characteristics, nutritional composition, and prebiotic potential of *Musa paradisiaca* cultivars Peyan and Monthan is essential to identify their potential for product development.

Thus, the current study was executed with the following objectives.

### **General Objectives**

#### **To**

- Explore the suitability of unripe banana flour of *Musa paradisiaca* cultivars Peyan and Monthan as adjuncts for Ready-to-Eat (RTE) and Ready-to-Cook (RTC) products.
- Assess the physicochemical properties, prebiotic, and antioxidant potential of unripe banana flours.
- Develop and evaluate unripe banana flours based Ready-to-Eat (RTE) and Ready-to-Cook (RTC) products.

### **Specific Objectives**

- Assess Consumers' Knowledge, Attitude, and Practice of RTE and RTC foods.
- Analyze the starch characteristics, functional properties, nutrients, and phytonutrient composition of unripe banana flours.
- Study the acceptability, nutrient composition, and shelf-life of the developed RTE and RTC products.
- Assess the prebiotic potential and predicted glycemic index (eGI) of the unripe banana flours and the developed RTE and RTC foods.