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Nutritional and Functional Potential of Green Banana Flour: A Comprehensive Review

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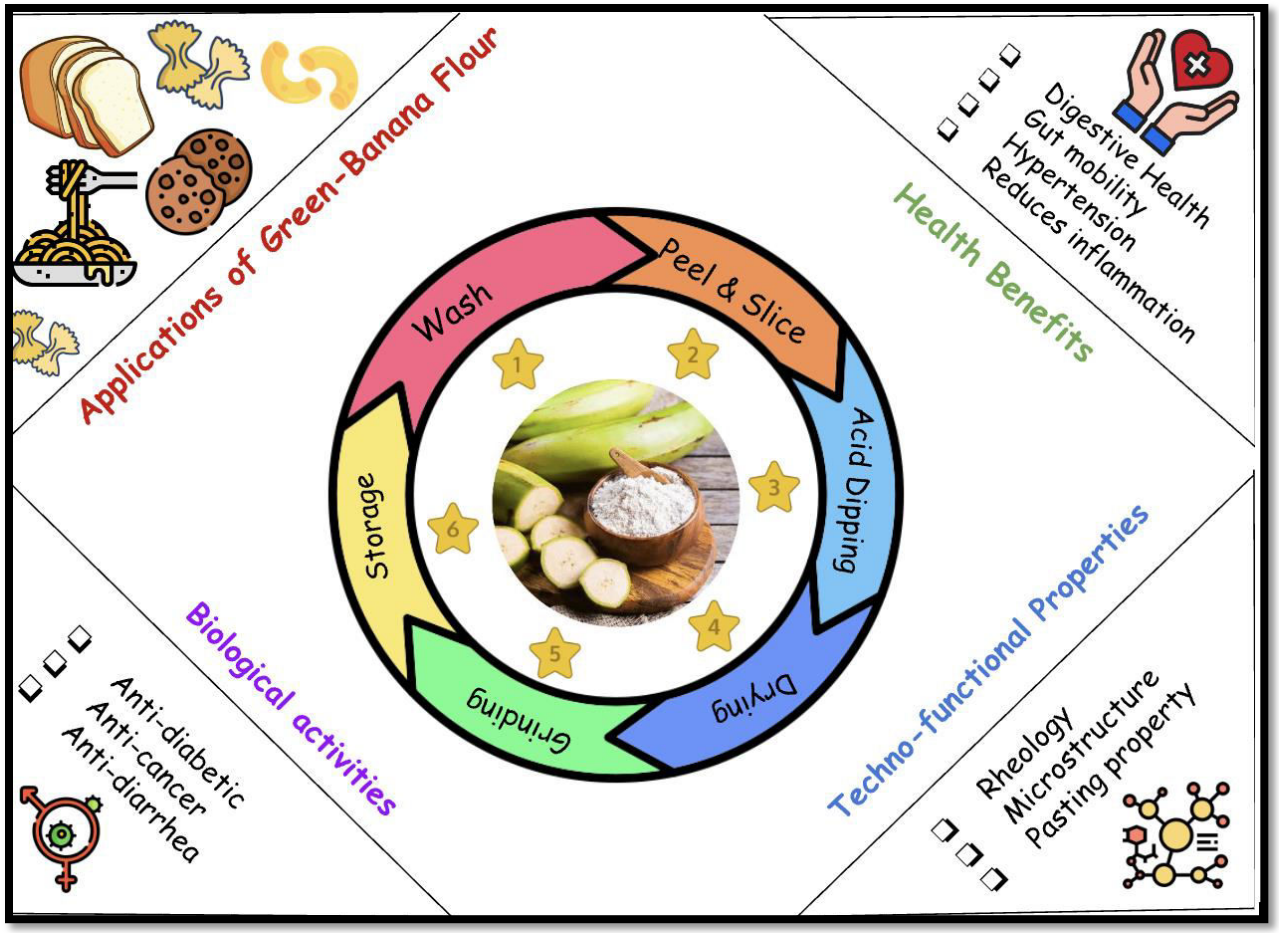
Abstract: Unripe bananas are used to make green banana flour, an unusual food component that is currently attracting significant attention for its remarkable nutritional and functional qualities. This in-depth analysis starts out by presenting green banana flour and explaining the techniques used in its manufacture and processing. This review discusses green bananas and flour's health benefits and functional potential in food applications. Of particular interest, producing banana flour is evaluated to their influence on flour's nutritional and functional properties. This in-depth analysis thoroughly explores the nutritional benefits and wide-ranging uses of green banana flour. It highlights the flour's rich supply of nutritional fibre, vitamins, minerals, and resistant starch, which provides health advantages and answers to the problems associated with malnutrition. The flour's excellent functional characteristics, such as its ability to hold onto water and oil, its emulsifying capabilities, and its prebiotic potential, place it in a valuable ingredient position with the ability to improve texture, increase shelf life, and enhance sensory qualities in a variety of food applications. This in-depth analysis discusses a wide range of issues with green banana flour. The detailed analysis of production and processing procedures is followed by an examination of the rich nutritional composition of the flour. The article also explores its many uses in value-added goods and prospective health advantages, such as its contribution to treating diseases including cancer, diabetes, and cardiovascular disease. Due to its high concentration of bioactive substances and antioxidants, green banana flour also shows tremendous potential in regulating blood sugar levels, controlling weight, and promoting digestive health. Its sustainable manufacturing practises, low waste output, and capacity to satisfy a variety of dietary choices make it a potential game-changer for the food business and for public health. To fully realise its potential and help create a more sustainable and health-conscious future, it is imperative to invest in ongoing research and development

Keywords: Green banana flour, Millet,Formulation development, Food processing, Shelf-life, Sensory evaluation, Digestibility, Food safety, Health benefits,Texture analysis, Product stability



Graphical abstract

1. Inroduction

The nutritional content of food is crucial for maintaining overall physical health and maximizing genetic potential. Prioritizing diet quality is essential to address food shortages and malnutrition effectively (Singh &Raghuvanshi, 2012). Functional foods contain bioactive components that offer health benefits beyond basic nutrition, helping prevent and manage chronic conditions (Arshad et al., 2021; Swanson et al., 2020).Fruits, including bananas, play a vital role in a balanced diet, providing essential vitamins, minerals, fiber, and bioactive compounds. The WHO recommends consuming at least 400g of fruits and vegetables daily to reduce the risk of chronic diseases (WHO, 2018; Rakotoniaina, 2017). Bananas are highly nutritious, aiding in the retention of calcium, phosphorus, and nitrogen, and offering energy for physical activities (Mizera&Mizera, 2019; Aljaloud et al., 2020).

Despite their low protein content, bananas are rich in potassium and other essential nutrients (Anyasi et al., 2013). Fertilization can enhance their nutritional value (Thangaselvabai et al., 2009). A study by Shankar et al. (2017) highlighted the nutritional composition of Musa acuminata bananas, revealing high protein and fiber

content. Bananas have been a staple in Southeast Asia and Africa for centuries and entered the global market about a century ago (Zaini et al., 2022).Recently, there has been increased interest in utilizing banana byproducts for their dietary benefits. Green bananas, rich in resistant starch, are considered a prebiotic food beneficial for gut health (Zaragoza et al., 2011; Zaini et al., 2022).

2. **Composition of Green Banana Flour** Banana Pulp: Banana pulp is rich in essential phytonutrients, including carotenoids, flavonoids, amines, and dietary fiber. Notable components include phenolic compounds and vitamins B3, B6, B12, C, and E. Phenolic compounds, such as phenolic acids and flavonoids, offer antioxidant benefits that combat oxidative stress and reduce the risk of chronic diseases (Fried and Nezin, 2017; Akbari et al., 2022). Vitamins in bananas support various health functions: B3 aids energy metabolism, B6 supports brain function, B12 is crucial for nerve health, C boosts the immune system, and E protects cells from damage. Carotenoids contribute to vision, skin health, and immunity, highlighting the health-promoting potential of bananas (Saras, 2023).

2.1 Dietary Fibers: Dietary fibers in green bananas include both soluble fibers (pectin) and insoluble fibers (cellulose, lignin, resistant starch). Soluble fibers dissolve in water, whereas insoluble fibers do not. Pectin can be extracted from banana peels, which are also rich in lignocellulosic biomass, useful for bioethanol production (Alba et al., 2018; Emaga et al., 2008).

2.2 Resistant Starch (RS): Resistant starch, particularly amylose, is fermented by beneficial gut bacteria, producing short-chain fatty acids like butyric acid, which helps prevent colorectal cancer (Kale et al., 2002; Amini et al., 2015). There are five types of resistant starch (RS1 to RS5), with green bananas being rich in RS2, promoting colon health (Khoozani et al., 2019; Singh et al., 2016).

2.3 Minerals: Green banana flour contains essential minerals, including potassium, magnesium, and phosphorus. Potassium is vital for muscle and nerve function, blood pressure regulation, and heart health (Soetan et al., 2010). Magnesium supports bone health, muscle function, energy metabolism, and blood sugar regulation. Phosphorus is important for bone and teeth formation, DNA synthesis, and carbohydrate and lipid metabolism (Dermience et al., 2010).

2.4 Bioactive Compounds: Both banana pulp and peel exhibit high antioxidant activity (Agama-Acevedo et al., 2016; González et al., 2010). Antioxidants in bananas help prevent lipid oxidation and rancidity, reducing the need for artificial preservatives (Pathak et al., 2017). Banana peel flour (BPeF) has higher concentrations of ash, protein, crude fiber, and digestible starch compared to the pulp, enhancing its value as a functional supplement (Nasrin et al., 2015).

2.5 Type and the amount of Green Banana Flour and the composition of green banana found in the study: (Table No 1)

Type of Banana	Carbohydrates	Proteins	Lipid	Ash	Resistant Starch	Reference
Musa cavendish AAA	60	1.9	0.4	0.8	16.3RBF	Ble-Castillo et al.
Musa paradisiaca	-	-	-	-	67.0UBS	Menezes et al.
Musa paradisiaca	55.6	14.7	17.59	-	-	Eleazu and Okafor
Musa paradisiaca	17.8	7.0	4.6	10.6	5gof RS/100 gof diet	Dan et al.

Abbreviations: db-Dry Basis, RBF-Raw Banana Flour, UBS-Unripe Banana Starch

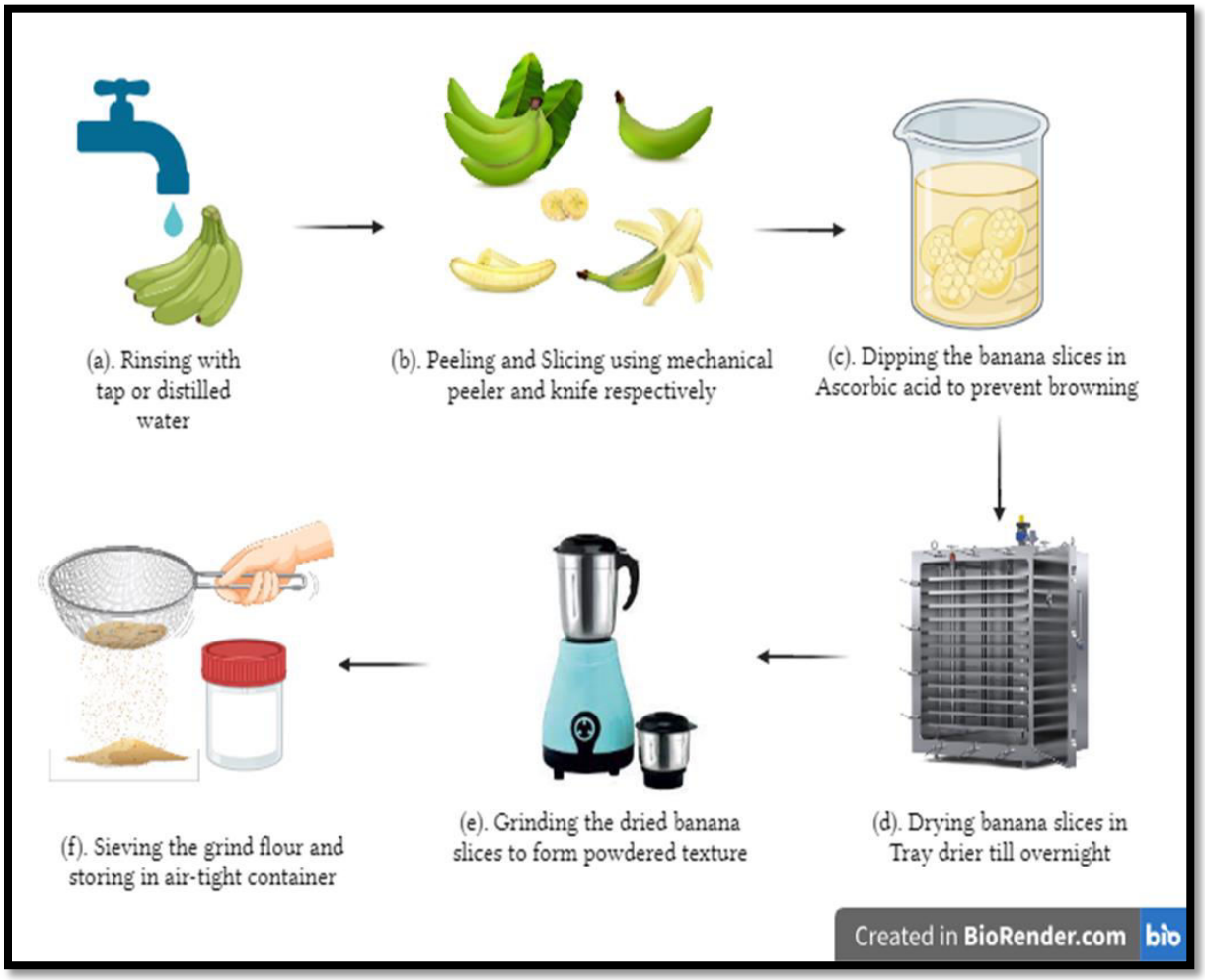
3. Green Banana Flour:

Bananas, being climacteric, deteriorate quickly, so drying is essential for extending their shelf life. Converting bananas into flour enhances storage potential due to its long shelf life and ease of incorporation into various foods (Haslinda et al. 2009). The drying method, source, type, and timing of the bananas influence the nutritional composition of the flour. The production of green banana flour is a simple process with significant benefits, such as increased shelf life and improved packaging efficiency, facilitating storage and transport (Yani et al., 2013). Utilizing banana flour minimizes post-harvest losses while preserving the nutritional value of fresh bananas. Unripe banana flour is rich in dietary fiber and resistant starch, beneficial for colon health. Green bananas, with approximately 26.95 grams of carbohydrates, are ideal for flour production. Research shows that flour from unripe bananas retains moisture better than that from ripe bananas (Singham et al., 2014; Kahler et al., 2022).3.1 Methods for green banana flour preparation:

Fresh green bananas are washed with tap or chlorinated water. Then it must be peeled with a mechanical peeler and slicing of size 1.5mm to 2.5mm diameter was done by using a knife. After the slicing was done, the slices were dipped into the 5% Ascorbic Acid to prevent the enzymatic browning. Slices are further kept in the tray drier for drying till overnight at 60 degrees Celsius. The initial moisture present in banana slices is decreased during drying. After completely drying, the slices are ground into a mixer grinder to form flour. Sieving has to be done from the obtained

flour and has to be stored in air tight container at room temperature (Zaroual et al., 2019)

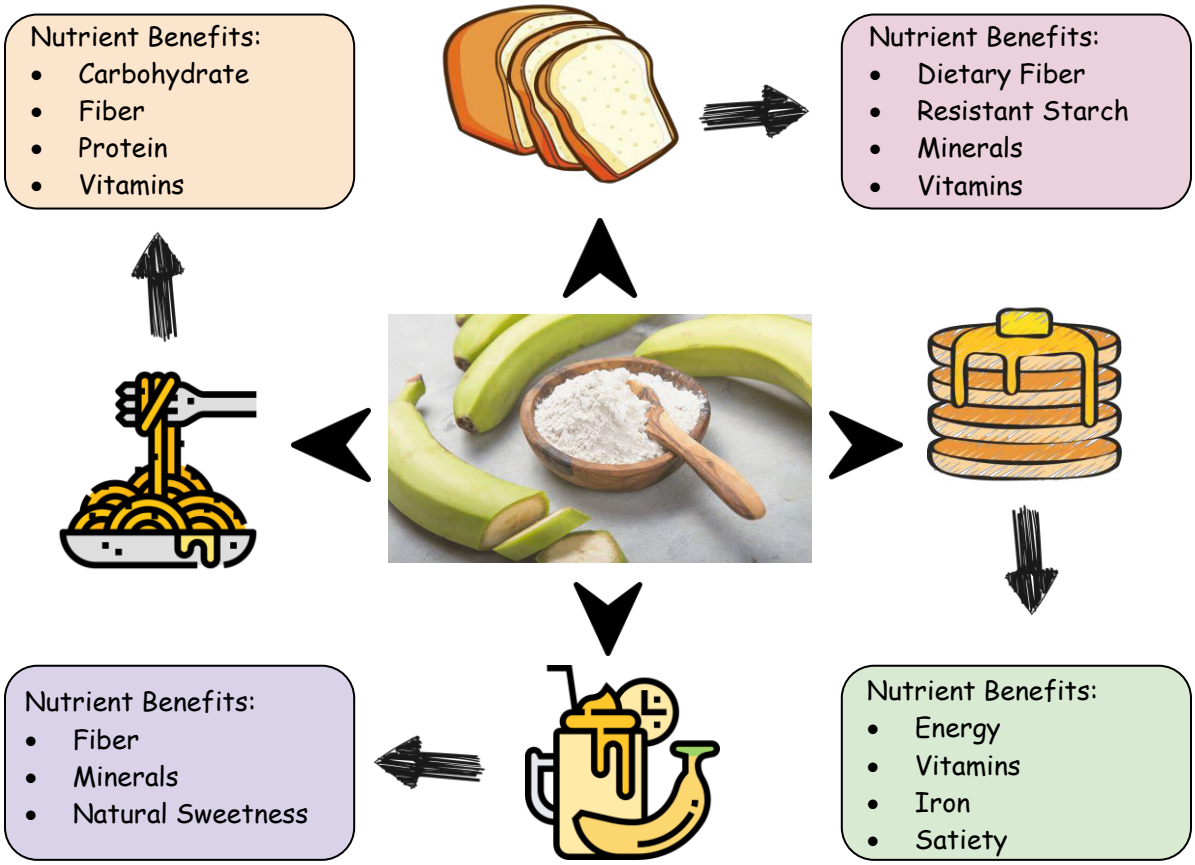
Fig No 1: Illustration for preparation of Green Banana Flour:



3.2 Chemical composition of Green banana flour: (Table No 2)

Banana Flour	Musa acuminata	Musa balbisiana	AmritsagarBanana
Moisture Content	7.70%	8.3%	6.46%
Ash	2.40%	1.2%	3.21%
Protein	1.05%	3.25%	2.75
Dietary Fiber	2.00%	1.8%	-
Fat	0.25%	2.06%	0.77%
Carbohydrates	86%	83.79%	87.74%
References	(Selvamani et al., 2009)	(Ansari et al., 2023)	(Kamal et al., 2022)

Fig No 2 Manufacturing and Applications of Green Banana Flour



4. Techno-Functional Properties of Green Banana Flour

Rheology:

GBF exhibits non-Newtonian flow characteristics, thinning with shear. Studies show variations in shear stress and gelatinization peak temperatures, indicating changes in starch organization (Acevedo et al., 2015; Ahmed et al., 2020).

Pasting Properties:

Heating starch-water solutions of GBF near gelatinization temperatures reveals changes in granule properties, with maximum viscosity indicating even granule interactions (Donmez et al., 2021; Schmid et al., 2022).

Microstructure:

GBF and green banana starch (GBS) show B-type and C-type crystalline structures in X-ray diffraction patterns, with minor variations in crystallinity (Fried &Nezin, 2017).

Health Benefits of Green Banana Flour

Bioactive Compounds:

Green bananas contain compounds like syringic acid, polyphenols, carotenoids, and dopamine, offering benefits such as diabetes reduction, anti-aging effects, cancer treatment, and cardiovascular health (Muthukumaran et al., 2013; Lokesh et al., 2014; Arora et al., 2008; Mattila et al., 2006).

Resistant Starch:

GBF, rich in resistant starch, aids in hunger reduction, increased satiety, and improved glucose management (Sarda et al., 2016). Studies on Musa paradisiaca show its potential in reducing type 2 diabetes and related cardiovascular risks (Arun et al., 2017). Research on rats indicates GBF promotes colonic fermentation, enhancing glycemic control and insulin sensitivity (Dan et al., 2015).

5. Effect of dietary intake of Green Banana on Various Diseases: (Table no 3)

Disease Name	**Bioactive Compound**	**Effect Due to Banana**	**References**	**Action of mechanism**
cancer	Phenolic Compounds, Vitamin C, Carotenoids	Antioxidant activities, antiangiogenic effect, and maximum cytotoxic activity	Dahham et al. (2015)	contribute to tumor growth inhibition.
Type-2 Diabetics	Phytochemicals, Low Glycemic Index	Low glycemic index, amylose content, and inhibitory action of α-amylase and α-glucosidase	Adedayo et al. (2016)	stabilizing glucose levels by slowing carbohydrate absorption, preventing sharp spikes in blood sugar after meals.
Ulcer	Low Acidity, Anti-Inflammatory potential	The antiulcerogenic effect induced by stimulation of gastric mucosa growth	Best et al. (1984)	minimizing acid-related discomfort and promoting ulcer healing and symptom relief
Bile-Disorder	Pectin, Antioxidants	By binding bile acids and	Kahlon et al., (2007)	reducing their reabsorption

	&Phytochemicals	utilizing a cholesterol-reducing drug		and promoting their excretion, Protecting the liver and bile ducts from oxidative damage
Strock	Potassium, Antioxidants, Magnesium & Vitamin B	Potassium availability decreased cerebrovascular diseases	Levine et al. (2002)	Regulating blood pressure, Reducing clot formation
Vitamin A deficiency	Carotenoids	Rich carotenoid content availability	Englberger et al. (2003)	When consumed, they are converted into active vitamin A
Plasma oxidative stress	Vitamin B6, Vitamin C, Dietary Fiber	Very low-density lipoprotein, Lipid peroxide	Yin et al. (2008)	neutralizing free radicals and mitigating oxidative damage
Hypertension	Vitamin B6, Antioxidants	Systolic blood pressure reduced significantly	Anindyah et al. (2015)	converting homocysteine into other non-harmful compounds, reducing blood vessel damage

6. Biological Activities of Green Banana

The banana plant offers various health benefits. Banana blossoms can treat ulcers, bronchitis, and dysentery, while the plant's astringent sap addresses hysteria, epilepsy, leprosy, fevers, hemorrhoids, and insect bites. Young leaves are used for burns and skin issues (Priscila&Renata, 2015). Components of bananas show potential medicinal benefits for conditions such as diabetes, hypertension, cancer, ulcers, diarrhea, urolithiasis, Alzheimer's disease, and infections. They are also used in food and pharmaceutical products, pain management, nanomedicine, pollution

control, apoptosis regulation, and cell cycle modulation. Bananas can treat intestinal issues and act as antibiotics against stomach ulcers (Deneo et al., 1996).

Anti-Diabetic Properties: Green Musa Chenkadali fruit ethanol exhibits antioxidant and hypolipidemic properties for diabetes treatment. Methanol extract from green Musa paradisiaca shows a hypoglycemic effect in normal and diabetic mice, suggesting its utility in managing type-2 diabetes mellitus (Ojewol et al., 2003; Deneo et al., 1996).

Anti-Cancer Properties: Eating fruits and vegetables, particularly green bananas, may lower colorectal cancer risk. The formula Cell Quest, derived from plantain, inhibits cancer cell ribosome activity and targets proteasomes in tumor cells, showcasing its anticancer potential. Higher banana consumption is associated with reduced breast cancer risk (Kazi et al., 2003; Zang et al., 2009; Acevedo et al., 2015).

Antidiarrheal Properties: Bananas' pectin content provides resistance to intestinal illnesses, showing anti-diarrheal effects in rat studies since the 1930s. Banana flakes are beneficial for critically ill patients receiving enteral nutrition (Omona et al., 2020; Borselino et al., 2019).

Antioxidant Properties: Bananas are rich in Vitamin C, crucial for tissue development, bone health, wound healing, collagen formation, and free radical defense. Vitamin C also supports hormone activation, white blood cell function, and proline hydroxylation, and it reduces cancer risk due to its potent antioxidant properties (Brown & Philips, 2010; Baranska et al., 2020).

New Evaluation Methods: Advanced techniques like spectroscopy, microscopy, and rheology quantitatively analyze the particle size, structure, and functional characteristics of banana flour, enhancing its potential applications in food products and ensuring better performance and quality (Wu et al., 2023).

8. Conclusion

Green banana flour, made from unripe bananas, offers significant benefits for the food industry and overall health. Rich in resistant starch, dietary fiber, vitamins, and minerals, it supports digestive health, glycemic control, and satiety, aiding weight management. This flour enhances sensory qualities like taste and texture in baked goods, making them more appealing. Its dietary fiber promotes digestive health, appealing to health-conscious consumers. Additionally, green banana flour helps extend the shelf life of food products by retaining moisture and reducing spoilage. These attributes make it a valuable ingredient in packaged foods, where freshness and longevity are crucial. Overall, green banana flour's nutritional profile and functional properties make it a versatile and beneficial addition to various food products, enhancing taste, texture, and shelf life while offering health benefits.

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