Processing Approaches and Product Development of Red Banana *(Musa Acuminata Var. Red Dacca)* Fruit Leather —An In-Depth Review

[1]***Aathirai Malar M A***
Department of Food Processing and Preservation Technology, Avinashilingam Institute for Home Science and Higher Education for Women Coimbatore (Tamil Nadu)
22uef001@avinuty.ac.in

[2]***Akshaya P***
Department of Food Processing and Preservation Technology, Avinashilingam Institute for Home Science and Higher Education for Women Coimbatore (Tamil Nadu)
22uef003@avinuty.ac.in

[3]***Swathi C S***
Department of Food Processing and Preservation Technology Avinashilingam Institute for Home Science and Higher Education for Women Coimbatore (Tamil Nadu)
22uef030@avinuty.ac.in

[4]***Dr A Reni**, Associate Professor ,*
Department of Food Processing and Preservation Technology, Avinashilingam Institute for Home Science and Higher Education for Women Coimbatore (Tamil Nadu)
reni_fppt@avinuty.ac.in

Abstract: Red banana *(Musa acuminata var. Red Dacca)* is a very nutritious tropical fruit. However, its fast ripening and soft texture can result in significant post-harvest losses. One effective way to tackle this issue is by turning the fruit into value-added products like fruit leather. This review looks at how to make red banana leather using simple and sustainable methods. Key steps include washing, pulping, heating the pulp at 80 °C, adding potassium metabisulphite, solar drying, and packaging. Solar drying is highlighted as a cost-effective and environmentally friendly method that helps maintain the natural color, flavor, and nutrients of the fruit. Proper pretreatment and drying enhance product safety and extend shelf life. Overall, solar-dried red banana leather offers a promising option as a healthy, natural snack and serves as a useful approach to reduce banana waste.

Keywords*: Red banana, fruit leather, solar dryer, KMS, value addition, dehydration, natural fruit products.*

I.INTRODUCTION:

Banana is one of the most popular fruits in tropical and subtropical areas and plays an important role in daily nutrition. Among the various types of bananas, red banana *(Musa acuminata var. Red Dacca)* has gained more attention because of its higher nutritional value and appealing look. Studies show that red banana has more dietary fiber, potassium, iron, anthocyanins, and phenolic compounds compared to common yellow banana varieties (Priya et al., 2019; Kumar et al., 2020). These beneficial components help with antioxidant activity and offer several health benefits, such as better digestion and less oxidative stress (Rajeswari et al., 2021).

Even with its nutritional perks, red banana is very perishable. As a climacteric fruit, it ripens quickly after harvest, causing it to soften, brown, and spoil. (Mishra et al. 2019) found that a significant amount of bananas are lost during post-harvest handling because of poor storage and transportation. This issue is worse for red banana due to its softer texture and higher moisture content. Thus, it is crucial to develop effective preservation and value-adding methods to lower post-harvest losses and improve usage.

Producing fruit leather has become an effective and easy preservation method for fruits with high moisture. Fruit leather is made by drying fruit pulp into thin, flexible sheets that keep much of the original flavor, color, and nutrients. (Sharma et al. 2020) noted that fruit leathers are popular because they are convenient, have a long shelf life, and are naturally sweet. Banana pulp is good for making leather due to its natural sugars and pectin, which help create a chewy texture without added sugar or binding agents (Diamante & Munir, 2014).

Drying is a key step in fruit leather processing, and the drying method affects the final product's quality. Recently, solar drying has become important as a sustainable and cost-effective option compared to traditional hot-air drying. Solar dryers work at moderate temperatures, helping to preserve heat-sensitive nutrients and natural pigments (Nambi et al., 2020). Lakshmanan et al. (2020) reported that solar-dried fruit products maintain better color and require less energy than mechanically dried products, making this method ideal for small-scale and rural processing units.

Pretreating fruit pulp before drying also plays a significant role in quality and shelf life. Heating the pulp at controlled temperatures can deactivate the enzymes that cause browning and reduce microbial load (Khan et al., 2021). Furthermore, using permitted preservatives like potassium metabisulphite helps keep the color stable and ensures the microbial safety of dried fruit products when used within recommended limits (Lakshmi et al., 2020).

In this context, this review focuses on recent research related to processing red banana leather using solar drying technology. It summarizes literature on the nutritional properties of red banana, fruit leather production, heating pretreatment, the use of potassium metabisulphite, and packaging. The goal is to highlight the potential of solar-dried red banana leather as a natural, nutritious, and sustainable value-added product.

II.LITERETURE REVIEW:

2.1 Nutritional Composition and Functional Potential of Red Banana

Red banana *(Musa acuminata var. Red Dacca)* has attracted notable scientific interest recently, thanks to its unique nutritional and functional traits. Red bananas have higher amounts of anthocyanins, carotenoids, phenolic compounds, and dietary fiber compared to standard yellow banana types. These compounds contribute to its rich red color and improved antioxidant activity (Priya et al., 2019). The presence of compounds like delphinidin and cyanidin derivatives boosts its ability to scavenge free radicals, positioning red banana as a promising ingredient for developing functional foods (Rajeswari et al., 2021).

The pulp of red banana is high in potassium, magnesium, and vitamin C, which are vital for heart health and immune function (Sathishkumar et al., 2021). The natural sweetness from its high sugar content means there is no need for added sweeteners in processed products (Kumar et al., 2020). Its soft texture and high moisture content make it ideal for puree-based products like juice concentrates, jams, and fruit leathers (Harini et al., 2021). Because of its natural pectin, red banana can form stable gels when dried, resulting in fruit leather with a pleasing chewy texture.

2.2 Post-Harvest Challenges and the Importance of Value Addition

Bananas are climacteric fruits that quickly ripen after harvest, increasing their vulnerability to damage, browning, and spoilage (Mishra et al., 2019). The softness of red bananas makes them prone to bruising and pulp breakdown, complicating storage and transport, especially in areas without cold storage facilities.

In India, post-harvest losses of bananas range from 30 to 40% due to poor handling and inadequate infrastructure (Rani et al., 2022). Farmers face more significant challenges marketing surplus red bananas because of their delicate structure. Adding value through dehydration, fermentation, or minimal processing can effectively reduce economic losses and improve the use of the fruit (Sundaram et al., 2022).

Producing fruit leather has become a practical way to use overripe bananas and cut down on waste. Fruit leather offers longer shelf life, easier portability, and convenience, making it suitable for both children and working adults (Sharma et al., 2020). Shelf-stable products like fruit leather provide more consistent income for farmers by ensuring profitable use of fruits that can’t be transported long distances.

2.3 Advances in Fruit Leather Technology

Fruit leather has been extensively researched as a value-added product for its versatility and nutrient retention. Its flexibility, shiny look, and chewiness depend on the natural sugars, organic acids, and pectin content in the fruit (Diamante & Munir, 2014). Banana varieties with high soluble solids create smoother and more cohesive leather sheets.

Achieving uniform pulp consistency is crucial for even drying and preventing surface cracks, with an ideal pulp thickness of 3 to 5 mm recommended for good drying and texture (Anandh et al., 2021). Factors like drying temperature, humidity, and air circulation significantly impact the final moisture content and sensory quality of fruit leather (Lakshmanan et al., 2020).

Formulations without added sugar are becoming more popular due to their health benefits and appeal to consumers looking for clean labels. These products keep more of the natural fruit flavor and identity, making them attractive to health-conscious buyers (Suresh et al., 2020).

2.4 Solar Drying

Solar drying is an eco-friendly and low-cost alternative to traditional drying methods. Solar dryers provide controlled conditions that prevent contamination and promote even moisture removal while working at moderate temperatures of 55 to 65 °C (Lakshmanan et al., 2020).

Indirect solar dryers have been shown to reduce drying time and nutrient loss compared to open sun drying while also keeping out dust, insects, and microbes (Nambi et al., 2021). Solar drying is especially suitable for producing fruit leather since it helps maintain the natural color, flavor, and antioxidants.

Fruits dried using solar technology retain more vitamin C than those dried in ovens (Alam et al., 2019). For red banana, keeping anthocyanins intact is essential for

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preserving color and antioxidant effects, which lower temperatures during solar drying help achieve. Solar drying also promotes sustainability by conserving energy and cutting carbon emissions. It is easily adoptable by small processors and rural communities (Sundaram et al., 2022).

2.5 Role of Potassium Metabisulphite (KMS) in Natural Fruit Preservation

Potassium metabisulphite ($K_2S_2O_5$) is commonly used in fruit processing for its strong antioxidant and antimicrobial effects. It inhibits polyphenol oxidase activity, stopping browning in banana products (Lakshmi et al., 2020). This is particularly important for red bananas, where anthocyanins and carotenoids are quite prone to oxidation.

KMS effectively controls microbial growth and stabilizes natural pigments during dehydration, making it suitable for long-term storage of dried fruits (Karthikeyan et al., 2019). When used within safe limits, KMS enhances shelf stability without introducing off-flavors. Its role is especially critical in formulations that skip acidulants like citric acid because it helps sustain color and safety (Sundaram et al., 2022).

2.6 Physico-Chemical and Sensory Quality of Banana Leather

The physical and chemical properties of fruit leather significantly affect its commercial acceptance. A moisture content of 12 to 15% is ideal to keep it flexible and stable on the shelf, while too much moisture encourages microbial growth and too little causes brittleness (Shamili et al., 2020).

Drying temperature affects color parameters such as L*, a*, and b* values. Solar-dried leathers show better pigment retention compared to oven-dried ones due to gentler drying (Meenakshi et al., 2021). Texture is vital for consumer acceptance, and natural pectin and sugars in banana contribute to a chewy and cohesive structure (Harini et al., 2021).

Sensory qualities like color, aroma, and taste are crucial for market success. Banana fruit leathers made without added sugar score better in flavor due to their natural sweetness and genuine fruit aroma (Suresh et al., 2020).

2.7 Engineering Properties of Fruits Relevant to Drying and Leather Preparation

Engineering properties such as flow behavior, thermal features, texture, and moisture movement are essential in designing drying processes and ensuring product quality. Banana pulp shows non-Newtonian, shear-thinning behavior, promoting even spreading and consistent thickness during drying (Subramani et al., 2019). Natural pectin adds to its stretchy properties, enabling the formation of cohesive films (Harini et al., 2021).

The high moisture content in red banana leads to better thermal conductivity, allowing quicker heat penetration during drying, which aids effective dehydration in solar dryers (Khan et al., 2021). Textural qualities like firmness and cohesiveness influence handling and drying characteristics, with soft banana pulp spreading well while being more prone to browning (Sivakumar et al., 2020).

Moisture movement increases with temperature, explaining why solar drying at 55 to 65 °C effectively cuts down drying time and microbial risks (Thirumaran et al., 2022). Surface stickiness from high sugar content can cause sticking during drying, which can be controlled by managing temperatures and using tray liners (Deepika et al., 2019). The optical properties like L*, a*, and b* values are key indicators of pigment stability, so controlled drying is crucial for keeping the characteristic red color of banana leather (Meenakshi et al., 2021).

IV.CONCLUSION:

The reviewed literature shows that red banana *(Musa acuminata var. Red Dacca)* is a nutrient-rich fruit with great potential for value addition. However, it faces high post-harvest losses because of its quick ripening and soft texture. Many authors point out that turning red banana into fruit leather is an effective way to preserve it. This method extends shelf life while keeping much of the fruit's natural color, flavor, and nutritional value. Making fruit leather is straightforward, affordable, and ideal for processing fruits with high moisture content like bananas.

The studies indicate that pretreating the fruit with controlled heating at around 80 °C plays a key role in reducing browning and microbial load. This process improves safety and quality. Potassium metabisulphite, when used within acceptable limits, has been shown to improve color stability and shelf life of dried fruit products. Solar drying is recognized as a sustainable and energy-efficient drying method. It works at moderate temperatures, preserving heat-sensitive nutrients and pigments while lowering processing costs.

In conclusion, the literature strongly supports developing solar-dried red banana leather as a natural, nutritious, and eco-friendly snack. Using this technology can help cut down post-harvest losses, boost farmer incomes, and support small-scale rural food processing. Further research on process optimization, packaging, and consumer acceptance can improve the market potential of red banana leather.

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