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Biochemical changes in enset (*Ensete ventricosum*) during post-harvest handling

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Abstract
Enset (*Ensete ventricosum*) is a crucial staple crop in Ethiopia, known for its role in food security. The plant undergoes various biochemical changes during post-harvest handling that affect its nutritional quality, shelf life, and sensory properties. This paper explores the enzymatic, metabolic, and microbial transformations occurring during the post-harvest processing of enset. The focus is on fermentation, storage, spoilage mechanisms, and the factors influencing these biochemical processes. A comprehensive understanding of these transformations is essential to improve post-harvest management and ensure better quality enset-based products.

Keywords: Enset (*Ensete ventricosum*), post-harvest biochemistry, fermentation, enzymatic activity, metabolic changes, microbial transformation, storage, food quality

Introduction
Enset (*Ensete ventricosum*), often called the "false banana," is a perennial plant primarily grown in Ethiopia, particularly in the southern and southwestern regions. Unlike other staple crops, the enset plant's corm and pseudostem are rich in starch and are processed into various food products, including kocho, bulla, and amicho. These products are integral to the diet of millions of people in Ethiopia. However, enset is perishable and undergoes significant biochemical changes after harvest, which influence the quality and safety of its products. Proper post-harvest handling is essential to preserve enset's nutritional integrity, prevent spoilage, and improve the storage life of its products. This paper focuses on the biochemical changes that occur during the post-harvest handling of enset, from enzymatic activities to microbial transformations, storage, and spoilage mechanisms.

Objective
The objective of this study is to investigate the biochemical changes in Ensete ventricosum (false banana) during post-harvest handling, focusing on enzymatic, microbial, and metabolic transformations. It aims to understand how these changes influence the quality, nutritional value, and shelf life of enset-based products, contributing to improved processing techniques.

2. Biochemical Changes during Post-Harvest Handling
The post-harvest period in enset is characterized by various biochemical transformations driven by enzymatic activities and microbial processes. These changes are critical for the texture, flavor, and nutritional quality of enset-based food products. Upon harvest, enset's biochemical composition undergoes changes that affect its starch content, microbial load, and the development of flavors.

One significant aspect is the enzymatic activity that occurs immediately after harvesting enset. The plant's starch is broken down by enzymes like amylase, which hydrolyze starch into simpler sugars. This breakdown process plays a crucial role in fermentation, which is a common post-harvest practice for improving the taste and nutritional profile of enset products. The activity of polyphenol oxidase (PPO) is another factor that leads to the oxidation of phenolic compounds, contributing to enzymatic browning in the tissues of enset. High levels of PPO activity are undesirable as they degrade the visual quality of the processed enset products.

Microbial activity, particularly from lactic acid bacteria (LAB), also significantly influences enset's post-harvest biochemical changes. LAB play a crucial role in the fermentation process by converting sugars into lactic acid, which helps lower the pH and creates an environment that inhibits harmful microorganisms. This fermentation not only improves the taste and texture of enset products but also increases the bioavailability of certain nutrients, such as vitamins and essential amino acids, while reducing anti-nutritional factors. In addition, yeasts and molds contribute to the flavor profile and preservation of the enset during fermentation.

During the fermentation of enset, several biochemical changes occur, including the breakdown of starches into fermentable sugars, the production of lactic acid, and the development of characteristic flavors. The quality of the fermentation process is affected by various factors, such as temperature, humidity, and microbial diversity, which influence the rate of microbial activity and the resulting biochemical products. This period of microbial fermentation is essential for improving both the nutritional and sensory qualities of enset-based foods.

Fig 1: Ensete ventricosum

3. Post-Harvest Storage and Spoilage Mechanisms

After harvesting and processing, enset is typically stored for future consumption. However, the biochemical stability of enset during storage can be compromised if proper handling measures are not followed. Storage conditions, including temperature, humidity, and the presence of contaminants, significantly affect the biochemical stability of enset-based products.

Temperature is one of the key factors that influence the rate of biochemical changes in enset. High temperatures accelerate enzymatic activities, such as starch hydrolysis and oxidative reactions, which can lead to a decline in the quality of the product. For instance, enzymatic browning, caused by the activity of polyphenol oxidase (PPO), increases when stored at elevated temperatures, reducing the visual appeal of the enset. In contrast, low temperatures can slow down enzymatic activities but may also promote microbial growth if moisture levels are high. Therefore, controlling the temperature during storage is crucial to prevent spoilage.

Moisture content plays a significant role in the microbial spoilage of enset. High moisture levels promote the growth of spoilage organisms, including molds and bacteria, which can lead to the production of mycotoxins and other harmful substances. Spoilage can also occur when there is a lack of proper fermentation or drying, leading to the retention of excess moisture in the enset products. Moisture control during storage is essential for maintaining the quality of enset-based products.

Antioxidants, such as phenolics and flavonoids, are important for maintaining the health benefits of enset. However, these compounds are sensitive to degradation during storage. Exposure to light, oxygen, and high temperatures can cause a decrease in the concentration of antioxidants, reducing the health-promoting properties of enset-based foods. Thus, minimizing exposure to adverse storage conditions is essential to preserve the nutritional value of enset during storage.

4. Challenges in Post-Harvest Handling

Post-harvest handling of enset faces several challenges that hinder the efficient processing and storage of the crop. One of the key challenges is the labor-intensive nature of traditional processing methods. Enset is traditionally processed manually, which is time-consuming and requires significant labor. This increases the chances of contamination and spoilage, particularly in regions where access to modern processing equipment is limited.

Another challenge is climate variability, which affects the rate of biochemical changes in enset. Changes in temperature and rainfall patterns can influence the moisture content of enset, which in turn affects microbial activity and enzymatic reactions. Furthermore, unpredictable weather conditions can reduce the quality of enset harvests, leading to a decline in the overall quality of the product.

Additionally, the lack of infrastructure and access to modern storage facilities in enset-growing regions limits the ability to manage post-harvest handling effectively. Inadequate storage facilities contribute to high post-harvest losses, as the products are exposed to environmental stressors such as temperature fluctuations and moisture. Without proper infrastructure, the shelf life of enset-based products is severely limited, leading to significant losses.

5. Recommendations for Improvement

To enhance the biochemical stability and quality of enset during post-harvest handling, several improvements can be made in the processing and storage practices. One key recommendation is the adoption of modern processing technologies that can reduce labor demands and improve the efficiency of fermentation. For instance, mechanical graters and fermentation tanks can ensure a more uniform fermentation process and reduce the risk of contamination.

Improving storage facilities is also essential to extend the shelf life of enset-based products. Temperature and humidity control systems, such as refrigerated storage and airtight packaging, can help maintain optimal storage

conditions and reduce spoilage. Additionally, the use of moisture-absorbing materials and improved drying techniques can further enhance storage stability.

Another recommendation is to implement climate-smart post-harvest practices that take into account the changing weather patterns. Using drought-resistant enset varieties and adopting water-efficient irrigation methods can help mitigate the effects of climate variability on enset production. Furthermore, training farmers in proper harvesting and storage techniques can improve the quality of enset and reduce post-harvest losses.

6. Conclusion

Post-harvest handling of enset plays a crucial role in determining the quality, nutritional value, and shelf life of enset-based products. The biochemical changes that occur during post-harvest processing, including enzymatic activities, microbial fermentation, and spoilage mechanisms, significantly impact the quality of the final products. By addressing the challenges related to labor intensity, climate variability, and infrastructure limitations, it is possible to improve the quality and shelf life of enset products. Adoption of modern technologies and climate-smart practices will contribute to enhanced food security and economic stability in enset-producing regions. Understanding the biochemical processes involved in post-harvest handling is essential to ensure the continued importance of enset as a food staple in Ethiopia and other regions.

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