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INDIGENOUS KNOWLEDGE FOR SUSTAINABLE AGRICULTURE DEVELOPMENT: BANANA RIPENING METHODOLOGIES FROM SOUTH AFRICA*

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Abstract. In South Africa, where bananas are produced commercially, small-scale farmers have traditionally used various Indigenous technologies to speed up the ripening process of the fruit. This vital Indigenous knowledge system greatly enhances food security, entrepreneurship, and sustainable livelihoods. However, the documentation of these processes is scarce in the scientific literature, risking their extinction. This study adopts a qualitative case study approach, using purposive and snowball sampling techniques to profile the technologies from key knowledge holders in Limpopo and Mpumalanga Provinces. The findings highlight the diverse and effective nature of these traditional practices, which utilise natural materials such as ashes, cow dung, chicken manure, local chambers, maize byproducts, and Indigenous leaves like Musudzungwane or Mugwiti. The motivation to sustain these Indigenous techniques includes their availability, accessibility, cost-effectiveness, and eco-friendliness. This research contributes to a broader understanding of Indigenous agricultural practices and emphasises the importance of continued documentation and integration of traditional knowledge within modern frameworks. Developing educational programmes aimed at transferring Indigenous knowledge to younger generations could help preserve and sustain this vital cultural heritage and improve the livelihoods of small-scale farmers.

Keywords: African Indigenous knowledge; agri-entrepreneurship; banana ripening; food security; rural development

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1. Introduction

Globally, Indigenous knowledge systems play a vital role in local development (Madonsela, Semenya & Shale, 2024; Stanly et al., 2024; Kom, Nicolau & Nenwiini, 2024). It offers sustainable, context-specific and locally adapted solutions rooted in centuries of rich knowledge and experience. From business, technology, and traditional farming techniques that preserve biodiversity to community-based resource management systems, Indigenous practices frequently align with ecological balance, environmental stewardship and long-term resilience (Olaniyan & Govender, 2023; Melash et al., 2023; Mbelebele et al., 2024; Dorji et al., 2024; Gebremichael, Didanna & Ayza, 2025; Fa & Luiselli, 2025). In regions affected by climate change, economic underdevelopment, food insecurity, poverty, and environmental degradation, integrating Indigenous knowledge and wisdom into development strategies can drive innovation, empower marginalised individuals and

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communities, and ensure that growth and development are inclusive and culturally respectful. Recognising and valuing this knowledge system is not only ethical but also economically strategic and viable.

The ripening of bananas, an essential process for their consumption and commercialisation, has historically been supported by various Indigenous techniques across Africa (Ajayi & Mbah, 2007; Sogo-Temi, Idowu & Idowu, 2014; Bantayehu & Alemayehu, 2020). Deeply rooted in cultural practices, these methods have been vital for small-scale farmers who rely on bananas as a staple crop and economic resource. Farmers in South Africa, a country producing bananas in significant commercial amounts, especially in rural areas like Mpumalanga and Limpopo, have developed Indigenous traditional ripening techniques that reflect their deep understanding of local environmental conditions and agroecological practices. These essential localised traditional methods, which have existed for centuries and are passed down orally through generations, are uniquely adapted to the resources available and serve as an alternative to costly modern banana ripening technologies. Despite their importance, however, these practices remain largely undocumented in scientific literature, leaving a conspicuous gap in understanding their contribution to sustainable agriculture and food security in South Africa and beyond.

The lack of scientific documentation of Indigenous banana ripening technologies in South Africa poses a significant threat to their conservation and development. This is because oral knowledge transmission, which historically was the primary avenue of passing on this essential Indigenous technique, is increasingly at risk due to shifting cultural dynamics and the ageing of knowledge custodians. As globalisation emerges, technology advances and communities modernise, thus influencing behaviours and practices (Balogun, Aruoture & Haruna, 2024; Tughhemba & Peter, 2024). Consequently, younger generations adopt new technologies, shifting from the initial African traditional oral-based typologies of knowledge dissemination and assimilation to conventional Western-oriented approaches. As a result, the rich heritage of Indigenous agricultural practices, such as Indigenous banana ripening methods, risks becoming obsolete.

The above argument on cultural dynamics and globalisation finds legitimacy in Akinola, Pereira, Mabhaudhi, Bruin and Rusch (2020), who maintain that Indigenous knowledge systems are frequently undervalued in contemporary research despite their potential to provide sustainable and context-specific solutions to challenges such as food insecurity and climate change. This worrying conception leaves a narrative that, without intentional efforts to adequately document, analyse, and integrate these Indigenous practices into modern agricultural frameworks, the vital knowledge may become extinct, depriving future generations of insights that could enhance resilience and innovation not only in banana farming but broader agrarian practices.

Substantiating the earlier advanced standpoints, profiling these Indigenous knowledge systems is not only a matter of conservation but also an essential step towards their improvement and potential integration with modern agricultural practices. In the current era of globalisation, no knowledge, skills or techniques exist in isolation; hence, every unique trait practised in silos must be recognised and integrated into the global landscape. Besides, like any technology, understanding traditional methods for banana ripening and principles is key to optimising their efficiency, scalability and efficacy. This process can also reveal opportunities to adapt these techniques to contemporary challenges, such as reducing post-harvest losses or enhancing the nutritional value of bananas. This is evident in Sekhar, Rastogi, Saikanth, Rout, Kumar and Patel (2024), who suggest that blending Indigenous knowledge systems with modern science will lead to innovative solutions that are both sustainable and culturally relevant to societies. Against these arguments, this study aims to bridge the critical knowledge gap by systematically profiling and analysing Indigenous banana ripening technologies traditionally used in rural areas of South Africa. It is believed that such efforts will contribute to their conservation, advancement, and potential integration into the broader web of agricultural practices.

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2. Global Overview of Banana Ripening Techniques

Banana ripening is a crucial process that influences the fruit's taste, quality, and marketability. Globally, many modern and traditional ripening techniques are utilised, reflecting cultural practices, regional resources, and technological advancements (Saranya et al., 2023; Laryea et al., 2025).

For instance, in Europe and North America, large-scale commercial ripening facilities use advanced modern ripening techniques such as ethylene gas chambers to ensure uniform ripening. These chambers maintain optimal temperature and humidity levels, allowing banana fruits to ripen uniformly during transit and storage before reaching end-point outlets like supermarkets (Paull & Chen, 2021). In Australia, similar advanced modern techniques are frequently employed to cater to domestic markets, where consumers demand visually appealing and high-quality banana fruits. Interestingly, countries like Japan have also adopted innovative techniques, including ripening banana fruits under controlled oxygen-depleted environments to enhance shelf life and appealing tastes - sweetness (Srilaong & Tatsumi, 2002). These advanced methods conform to global market demands and highlight the shift toward mechanisation and precision in agricultural practices. While conventional methods offer consistency and quality control, traditional ripening techniques, especially Indigenous techniques, are still widely used in developing regions and emphasise the importance of cultural conservation and resource optimisation.

A similar trend was observed in South Asia, particularly in India and Bangladesh, where ethylene gas from kerosene lamps and small coal-fired chambers is traditionally utilised to hasten the ripening of banana fruits (Islam et al., 2016; Zore et al, 2021). Parallel to the former, in parts of Latin America, including countries such as Colombia and Ecuador —major banana exporters—banana fruits are ripened in controlled environments using techniques like ethylene gas chambers (Ruiz Medina & Ruales, 2024). These chambers allow for symmetrical ripening and precise control over temperature and humidity, ensuring the ripened fruits meet international quality standards. This technique, although effective, has ripple effects, especially health and environmental concerns, due to its inherent potentially hazardous materials. Some artificial mechanised ripening techniques that rely on chemical agents can lead to alterations in the active components of banana fruits, potentially causing physiological issues in human beings (Chandar & Smith, 2019). For instance, chemicals such as calcium chloride, calcium carbide, ethephon, and ethylene glycol frequently utilised in the banana ripening process, have potential health hazards (Chandar & Smith, 2019), emphasising the need for prioritising natural or less harmful ripening techniques to ensure food safety. Natural banana fruit ripening techniques provide the most beneficial effects without posing toxicity risks to health, making them safer for consumption.

In ancient Sri Lanka, natural techniques involving smoking were a traditional and efficacious approach to ripening bananas, achieving nearly 100% success (Ranaweera, Ampemohotti & Arachchige, 2020). Smoke is generated by burning semi-dried leaves and directed into the pit to sulphonate the banana fruits, thus accelerating their ripening process naturally (Maduwanthi & Marapana, 2019). This method leverages heat and ethylene production from the smoke to enhance ripening and achieve the desired results. The smoking process increased the temperature conditions around the banana fruits, which stimulated the production of ethylene - a natural hormone responsible for ripening the fruits. Storing banana fruits at this elevated temperature expedited the natural ripening process, resulting in softened, swift ripened process. Like most other natural methods, this technique allowed for the acceleration of banana ripening without the use of harmful chemicals, making it not only safe for human consumption but also an eco-friendly technique. However, this technique's ripening process was somewhat complex, resulting from deficiencies in advanced tools, skills and technical knowledge at the time, thus leading to its gradual underutilisation.

Raw agricultural wastes, such as wheat grain and rice straws, were another documented natural harnessed ripened banana fruits techniques in traditional agricultural practices in Asia (Chandar & Smith, 2019). The process

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involves placing the bananas in a confined space, layered with the materials. These organic materials are active in creating a warm and humid environment in the space, which accelerates the fruit ripening process by trapping ethylene gas - a natural plant hormone released by banana fruits that enhances ripening. The insulation provided by the straw or sawdust facilitates even heat distribution in the environment and minimises moisture loss, resulting in a uniformly ripened process with enhanced flavour and texture. A notable implication of this technique is that it is both cost-effective and eco-friendly, making it a sustainable alternative to artificial mechanised ripening agents frequently used. These Indigenous methods are valued for their simplicity and cost-effectiveness, particularly in rural areas where access to modern ripening technologies is limited. It also reflects the deep-rooted Indigenous knowledge of local communities in leveraging available resources and local practices for agricultural processes. However, the lack of standardised processes for these Indigenous methods frequently results in inconsistent ripening processes, ultimately affecting small-scale farmers' marketability and income.

3. Methodology

This study was conducted in the Limpopo and Mpumalanga Provinces in South Africa. The choice of location hinges on tremendous banana production and marketing endeavours in the area compared to other provinces. An exploratory qualitative case study research methodology was employed, utilising a participatory community-led action research approach. This approach aimed to identify the Indigenous techniques for ripening banana fruits in the areas and the motivation for the practices. The essence of participatory action research hinges on the need to facilitate robust engagements with grassroots knowledge holders to profile the banana species, enabling knowledge conservation and transfer.

Essential knowledge holders were purposively sampled through key informants and research assistants to engage in the study. This sampling technique was ideal for identifying well-endowed knowledge holders with extended experience in banana production in the study area. Subsequently, more participants were snowballed into the circle until the saturation threshold was reached, that is, a point where information gathered from additional members on the subject matter was insignificant to the former. At this point, 144 participants had been engaged through a focus group physical contact discussion of 9 members each, using a semi-structured questionnaire. In all, 16 focus group discussions were held. Five grassroots farmers with advanced experience and knowledge of banana production in the locale were interviewed using a one-on-one technique, bringing the total number of participants to 149. This data collection engagement spans from May 2022 to June 2023, aside from inception preparations and community entry arrangements that were not reported. The collected data excerpts were then transcribed into 21 documents (D) in line with the focus groups and input into the Atlas-ti v8 software for analysis, utilising an open coding system for sentiment analysis. This facilitated the organisation and modelling of the data to identify key contents and patterns related to the banana species and farmers' rationale for venturing into them.

4. Findings

Seven banana-ripening Indigenous techniques emerged from the analysis. As illustrated in Table 1, this includes Ash, Tree leaves, Local Chamber, Animal Faeces, Maize byproducts, Tree leaves, and Fruits. The adoption and conservation of these techniques from one generation to another hinges on their cost-effectiveness, availability of agents, natural ripening process, and original taste retention.

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Table 1. Banana fruit Indigenous ripening technique in Limpopo and Mpumalanga

Technique	Motivation	Process	Timeframe	Limpopo	Mpumalanga
Ash 	Affordable Availability Fast ripening	The banana is covered with ashes and sealed with a sack to absorb heat. It takes a maximum of one week to reach the expected ripened threshold.	7 days	X	
Tree leaves 	Affordable Availability Fast ripening Natural taste Yellow color	The harvested banana fruit is split evenly and sealed in sack bags or wrapped in blankets alongside tree leaves called Musudzungwane. To ripen, it is stored in confined spaces, like Nkho – clay pots, calabash, iron pots, bins, trunks, drums, and ground holes.	5-9 days	X	X
Local Chamber 	Affordable Availability Fast ripening Healthy Long shelf life Natural taste	A bunch of bananas are stored in Dulu, a confined structure made of wood, mud, and stones with grass roofing.	days	X	X
Animal Faeces 	Eco-friendly Fast ripening	Split banana bunches are wrapped with newspapers and sealed in a sack bag alongside chicken manure or cow dung to ripen my bananas.	7days	X	
Maize byproduct 	Affordable Eco-friendly Organic Natural taste	The banana bunch is split evenly and sealed in a sack alongside Mufumbu - coarse residue from maize powder.	1-2 weeks	X	
Tree leaves 	Affordable Available Eco-friendly Natural taste Organic	Mugwiti Indigenous tree leaves are positioned between bunches of bananas, packed in a sack.	7 days	X	
Fruits 	Affordable Available Eco-friendly Natural taste Organic	The banana fruits, combined with granadilla fruits or ripe banana peels, are either sealed in a sack bag or put in a container and covered with boxes.	7 days	x	x

Source: Authors' consolidation based on primary data

4.1. Ash technique

In many rural areas of Africa, traditional agricultural practices are not just a means of cultivation, but a reflection of deep-rooted Indigenous knowledge passed down through generations. These practices, frequently overlooked in modern agricultural discourse, provide insights into sustainable farming techniques that have stood the test of time. In Limpopo and Mpumalanga provinces, small-scale entrepreneurs utilise a unique and time-honoured method to ripen banana fruits, a staple food crop in South Africa. The expression below captures the detailed

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ripening process shared by one of the local farmers who participated in this study, emphasising the significance of Indigenous African banana ripening techniques in maintaining food security and cultural heritage.

"When I ripen the banana, I use ashes. I cover the banana with ashes and put it in a sack to absorb heat. Then, the sack is tied very tightly so that no air penetrates. After a week or so, the banana is ripe and ready to be eaten. This process typically takes a week for the banana fruits to ripen evenly and be ready for either household consumption or sale."

As explained by one of the knowledge holders, this practice reflects a process rooted in a profound understanding of local environmental conditions. Using ashes, the banana fruit entrepreneur ensures heat retention and prevents air from interfering with ripening. The tightly tied sack creates an atmosphere conducive to the uniform ripening of the banana fruit, showcasing a low-cost and resource-efficient technique that leverages locally available materials. Ashes, a byproduct of wood or plant material combustion, are teeming and accessible in these rural settings, as many rely on traditional fire cooking methods. The ashes serve a dual purpose: 1) heat retention, which accelerates the ripening process, and 2) creating a semi-sealed environment that limits the exposure of the fruit to oxygen, thus controlling the rate of ripening. Similarly, sealing the bananas in a sack minimises the external variables like humidity and air circulation that could affect the ripening process. This method is particularly effective in ensuring that the fruits ripen evenly without the risk of them spoiling prematurely.

4.2. Tree leaves

The technique described is one of several Indigenous methods frequently utilised in the local areas to ripen bananas. Another stakeholder sheds light on one such traditional method involving using a clay pot, known as Nkho, and a variety of Indigenous tree leaves to ripen bananas, offering insight into the ingenuity and resourcefulness of local farmers. The process involved in this technique begins with carefully harvesting bananas and dividing the large bunches into manageable portions. In the past, clay pots were frequently used for this technique; however, the disappearance of some traditional practices, which made the pots scarce, resulted in the adaptation of alternate means such as metal drums, bin containers and boxes. Despite this shift, the essence of the ripening process remains rooted in Indigenous knowledge, particularly the use of Indigenous leaves. When placed in a confined space like clay pots, these leaves release heat, creating a microenvironment within the box that accelerates the ripening process.

"Long back, we used a clay pot named Nkho or a box and even bin containers to ripen the bananas. When the bananas have grown big and are ready for harvest, we would cut the bunch from the tree. We would divide the bananas from the bunch, steam and put them inside the clay pot. Furthermore, we would cut a traditional tree named musudzungwane put the leaves on top of the bananas and close it for ripening. When it gets ready after 5 days, it will be very appealing with a nice yellow colour. The banana does not release sweat or water when it is ripened using Nkho and Indigenous tree leaves."

In this traditional method, the clay pot, Nkho, is crucial in creating the ideal microenvironment for ripening bananas. The pot's material allows for a stable, insulated environment that regulates temperature and humidity, crucial factors in the ripening process. The choice of musudzungwane leaves is equally significant, as they likely possess properties that either aid in the ripening process or prevent the bananas from sweating or releasing excess moisture, which can lead to spoilage. By placing the bananas inside the Nkho and covering them with these specific leaves, the farmer creates a controlled environment that allows the bananas to ripen evenly and attain a desirable yellow colour without the risk of them becoming overly soft or spoiled. The process typically takes around five days, after which the bananas are ripe and visually appealing, making them ideal for consumption or sale.

4.3. Local chamber

In the Mpumalanga Province, one such traditional method involves using a Dulu structure for ripening bananas. Dulu is a small local storage room usually built by women with mud, wood, stones, and grass, where bananas are stored to ripen. Its relative lack of air space, windows, and small size make the room dark with warm

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temperatures, regardless of the atmospheric conditions outside. This banana ripening process not only reflects the community's resourcefulness in harnessing Indigenous knowledge systems and deep understanding of local environmental conditions but also highlights the important role of women in sustaining these traditions:

"What we do is go to the field and cut wood and bring it home, and we make a circle using stones, covering the whole place with wood in a circular form. Moreover, women would use mud to cover the places where air can penetrate from inside to outside, and the structure is also roofed with long grass. When the banana is ready for harvesting, we put it inside the Dulu structure for it to ripen. After 5 to 7 days, the banana will be ready for consumption." "We ripen the banana using Dulu, which is a structure made of wood, stones, and grass, with grass roofing. Women were ordered to use mud to patch the spaces where air could penetrate inside the Dulu. Then, the banana is placed there to ripen, and after 7 days, the banana is ready to be consumed." This Dulu technique prevents premature spoilage and ensures banana fruits develop a desirable texture and flavour."

The Dulu storage is an ingeniously constructed ripening chamber that relies on locally sourced materials, such as mud, grass, stones, and wood, to create a controlled environment suitable for the ripening of banana fruits. The chamber is built in a circular form, with wood forming the primary enclosure. Subsequently, stones are placed around the base of the chamber to support the wooden walls and ensure stability. Once the basic framework is structured, the pivotal step of sealing the structure is carried out. Women play a critical role in the process, as they apply mud to patch any gaps or spaces where air might penetrate the chamber, which is essential for maintaining the necessary humidity and warm temperature levels inside to hasten the ripening process. The grass roof provides additional insulation, which ensures that the atmosphere inside the Dulu chamber remains consistent.

4.4. Animal Faeces

Due to its cost-effectiveness and availability, the chicken manure and/or cow dung banana ripening technique is also employed in Mpumalanga. This expression below, an extract of one of the stakeholders who participated in the study, highlights how these natural materials, along with other household items, are utilised to create a controlled environment for ripening banana fruits, showcasing a unique blend of practicality and the Indigenous knowledge system in South Africa.

"I use chicken manure or cow dung to ripen my bananas. I put them in a sack, then add the manure inside along with some newspaper to provide warmth. After that, I cover the bananas with blankets, place them back in the sack, and leave them to ripen. After about a week, an aroma signals that the bananas are ready to be eaten."

This process reflects a practical and sustainable approach to ripening bananas, using organic materials that are readily available and easily accessible to small-scale farmers. In these rural areas, many households have rare cattle, sheep, goats and chickens for domestic consumption and commercial purposes. This animal dungs serve as a natural source of heat, generating the warmth required to accelerate the banana fruit ripening process. When kept in a semi-enclosed space like a sack bag, pot or drum, these materials release heat slowly, thereby creating an ideal microenvironment within the space, further insulated by layers of newspaper and blankets. In this context, a semi-enclosed space is needed to generate and trap the necessary heat for ripening while simultaneously allowing the fruits to breathe, preventing excessive moisture buildup that could potentially lead to spoilage even before it ripens to the desired stage. These elements, combined, help maintain a consistent temperature around the banana fruits, allowing them to ripen evenly in a week. While it appears simple, this technique is an effective approach to ripening banana fruits naturally without the need for modern technology, and it exemplifies how grassroots farmers in rural communities of South Africa maximise the available resources in their entrepreneurial endeavours.

4.5. Maize byproduct

Mufumbu, a byproduct derived from the processing of maize, is one such time-honoured Indigenous banana ripening technique in rural communities. The process of obtaining Mufunbu involves grinding dried maize using

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traditional tools—Mutuli and Musi—into a fine powder form. The coarse residue left after shifting to separate the fine maize powder is known as Mufumbu. This maize byproduct, Mufumbu retains a significant amount of heat, making it ideal for efficiently and naturally ripening banana fruits. One of the knowledge holders explains that:

"To ripen the banana fruits, I cut a bunch from the tree, then place it in a sack. I then pour the Mufumbu substance into the sack, ensuring that it surrounds the banana fruits. Once the Mufumbu is in place, I tie the sack securely and cover it with a blanket to help retain the heat. In just a week, the heat from the Mufumbu gradually enhances the banana fruits to ripen. The process is efficient, and after seven days, the bananas are ready for consumption."

Mufumbu's unique heat properties make it an ideal medium for ripening banana fruits. Positioning the banana fruits in a sack and surrounding them with Mufumbu, the local farmers create a warm, insulated atmosphere that accelerates ripening. The use of a blanket further traps heat inside the sack. The ripening technique is effective and resource-efficient, as it utilises a maize byproduct that might otherwise go unused.

4.6. Fruit techniques

Using Indigenous plants and locally available materials like granadilla fruits or ripe banana peels as traditional practices for ripening fruits has long been an essential part of agricultural life in many rural communities, reflecting deep connections to the natural environment and the resources it provides. This technique entails placing ripened banana peels and/or granadilla fruits on the newly harvested bananas and sealing them in the same sack.

"Once the bananas are inside the box, I put some granadilla fruits and ripe banana peels, then cover the box. The fruits and peels are known for generating heat, creating the ideal environment for ripening the bananas. After about a week, the bananas turn a vibrant yellow, signalling that they are ripe and ready for the market. The beauty of this technique is that it ensures all the bananas ripen naturally and uniformly—no sides are left green. This technique is quite similar to another traditional technique using the leaves of an Indigenous tree, which is also known for its effectiveness in ripening bananas."

The effectiveness of this method can also be attributed to the unique properties of the granadilla fruits, which have been recognised for generations for their role in other fruit ripening. Similar results can be achieved using ripe banana peels, a byproduct with comparable heat-producing characteristics. These natural methods ensure that the bananas are ready for consumption or sale promptly and preserve the fruit's quality and colour, making them more attractive to buyers.

5. Discussion of Findings

In Africa, banana fruit ripening techniques, specifically in South African rural areas, are deeply rooted in Indigenous knowledge systems and traditional practices, particularly among small-scale farmers who rely on accessible resources and cost-effective methods (Bantayehu & Alemayehu, 2020). Common practices in this context involve using organic resources such as ashes, chicken manure, cow dung, or maize byproducts to accelerate the banana fruit ripening process. Frequently, these materials are placed in a confined space, such as local pots, sacks, and traditional chambers made of clay, wood, stones and grass alongside the bananas to create warmth and mimic the ethylene gas production that facilitates even ripening. Another notable technique uses the leaves of Indigenous trees such as *Mugwiti* or *Musudzungwane* to cover banana fruits placed in containers, sacks, or any other confined space. The leaves generate heat, temperature, and moisture in the confined space, aiding in the fruits' uniform ripening while enhancing the bananas' flavour and texture. The materials involved in these techniques are not only affordable at the disposal of the local farmers but also eco-friendly and void of health implications, as they minimise chemical use and repurpose natural resources.

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Some of these techniques align with traditional banana fruit ripening practices that exist in other regions of the world. For example, in Asia, local farmers commonly and frequently utilise ethylene-releasing organic materials like rice straw or sawdust to ripen bananas (Maduwanthi & Marapana, 2019). A similar pattern was observed in parts of Sri Lanka, where banana farmers use earth pits or clay pots to trap heat and ethylene gas (Chandar & Smith, 2019; Ranaweera, Ampemohotti & Arachchige, 2020). This creates optimal conditions for ripening the fruits evenly. These practices, like those in South Africa, demonstrate a reliance on locally available materials and emphasise the ingenuity of smallholder farmers in adapting to their environments. The use of plant materials, such as banana leaves by local farmers in Latin America and *Musudzungwane* leaves in South Africa, highlights the universal reliance on natural resources to achieve desired banana fruit ripening outcomes.

Despite regional variations, the underlying principle of these traditional banana ripening techniques globally is the creation of a controlled atmosphere to facilitate even fruit ripening, frequently through the manipulation of heat and ethylene gas levels in a confined environment. However, South Africa's Indigenous banana ripening practices differ in their emphasis on specific local resources such as ashes, tree leaves, animal faeces, and maize byproducts, reflecting the region's unique cultural heritage and environmental contexts. Profiling and preserving these traditional techniques are crucial, as they offer sustainable alternatives to the usual contemporary commercial use of artificial banana fruit ripening agents like ethylene gas chambers, that is relatively expensive, as well as calcium carbide, which is banned in many countries resulting in from health-associated risks of the method (Food and Agriculture Organization [FAO], 2020). Drawing parallels between South Africa's Indigenous ripening techniques and those of other regions, it becomes evident that traditional banana fruit ripening practices are valuable for their cultural importance and promise global knowledge-sharing for sustainable agricultural innovations.

Conclusions

Banana ripening techniques in South Africa showcase the richness of the Indigenous knowledge system and the resourcefulness of small-scale farmers who rely on accessible, cost-effective, and eco-friendly methods to achieve optimal ripening outcomes. Using natural materials such as ashes, cow dung, chicken manure, local chambers, maize byproducts, and Indigenous leaves like Musudzungwane or Mugwiti reflects an environmentally conscious approach rooted in African cultural traditions. Although slightly different, these practices align with global methods observed in Asia, where farmers in India and Sri Lanka similarly utilise locally available resources, such as rice straw, wheat grain, banana leaves, and earth pits, to create controlled ripening environments. Such similarities emphasised the universal reliance on natural processes while highlighting the uniqueness of South Africa's adaptation to its specific cultural heritage and ecological contexts.

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