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Meta-Analysis of Sweet Potato Storage Methods and Their Impact on Quality

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Abstract Sweet potato is a globally significant staple crop known for its high nutritional value, yet maintaining quality during storage remains a persistent challenge. This study reviews traditional and modern storage techniques, comparing their effectiveness in preserving nutritional, physical, and sensory qualities, as well as extending shelf life across diverse regions. Employing rigorous selection criteria, we synthesized data from various studies, analyzing the influence of temperature, humidity, variety, and pre- and post-harvest practices on quality outcomes. Findings reveal that modern storage innovations, particularly those with controlled temperature and humidity, significantly improve quality preservation compared to traditional methods. However, the accessibility and environmental impact of these methods vary, raising considerations for sustainability and cost. The case study included highlights regional storage practices and their outcomes, offering insights for broader application in sweet potato cultivation areas. This analysis underscores the need for further research to address data gaps, optimize storage methods for different sweet potato varieties, and develop cost-effective, sustainable solutions for quality maintenance. Future research should explore the integration of modern storage methods with regional practices, providing a pathway to enhance storage efficacy for improved nutritional and economic value of sweet potatoes globally.
Keywords Sweet potato storage; Meta-analysis; Quality preservation; Nutritional quality; Storage techniques

1 Introduction

Sweet potato (*Ipomoea batatas* L.) is a vital staple crop globally, known for its high nutritional value and adaptability to diverse climatic conditions (Sun et al., 2014). It is rich in essential nutrients such as vitamins A and C, dietary fiber, and antioxidants, making it a crucial component of diets in many regions (Karan and Şanli, 2021; Escobar-Puentes et al., 2022). The crop's versatility allows it to be cultivated in various environments, from tropical to temperate zones, contributing significantly to food security and economic stability in many developing countries (Mekonen et al., 2022).

Despite its nutritional benefits, maintaining the quality of sweet potatoes during storage poses significant challenges. Factors such as temperature, humidity, and susceptibility to diseases can lead to quality deterioration, affecting both the nutritional content and market value of the tubers. (Mitra et al., 2010) For instance, storage temperatures play a critical role in preserving the quality of sweet potatoes. Research indicates that higher storage temperatures (e.g., 15°C) can reduce tuber waste and weight losses due to germination, transpiration, respiration, and rotting, compared to lower temperatures (e.g., 5°C) (Krochmal-Marczak et al., 2020). Additionally, infections such as *Fusarium solani* can cause severe quality deterioration, leading to the accumulation of toxic compounds like ipomeamarone and significant metabolic changes in the tubers (Li et al., 2022). These challenges necessitate the development of optimized storage methods to ensure the prolonged quality and shelf-life of sweet potatoes (Dong et al., 2019).

This study seeks to determine the most effective storage conditions and practices to minimize quality loss and extend the shelf life of sweet potatoes by analyzing data from multiple studies, covering assessments of various storage temperatures, humidity levels, and disease management strategies on the nutritional and physical qualities of sweet potatoes. This study aims to provide actionable insights and recommendations for farmers, storage facility managers, and policymakers to enhance storage stability and quality, ultimately contributing to improved food security and economic benefits through comprehensive analysis.

2 Storage Methods for Sweet Potatoes

2.1 Traditional storage techniques

Traditional storage techniques for sweet potatoes often involve methods such as pit storage, sack storage, wooden boxes, and clump storage (Figure 1) (Bhattarai et al., 2021). These methods are widely used in various regions due to their simplicity and cost-effectiveness. For instance, in the Gamo Zone of Southern Ethiopia, sweet potatoes stored in pits showed the highest moisture, ash, protein, fat, and fiber content compared to other traditional methods, with the least weight loss, sprouting, and spoilage over a four-month period (Eyesa and Badebo, 2022). This suggests that pit storage is preferable for maintaining the physicochemical and sensory acceptability of sweet potatoes. However, traditional methods like sun or open-air drying, although common, can be slow and may result in lower quality due to prolonged exposure to environmental factors (Rashid et al., 2022).

Figure 1 Different storage conditions and sweet potato genotypes (Adopted from Bhattarai et al., 2021)
Image caption: A-inside dry sand; B-inside sawdust; C-thin jute sack; D-natural mud pot; E-open crates; F-'CIP 440015'; G-'CIP 440267' and H-'Local White' (Adopted from Bhattarai et al., 2021)

In Zhejiang China, sweet potatoes are usually concentrated on the market in November. In order to extend the supply of fresh potatoes and processing time, they are generally stored for more than three months with a decay rate of about 30%. To this end, Jinhua Academy of Agricultural Sciences and Zhuji Chunjiahe Agricultural Technology Co., Ltd. have developed a set of simple greenhouse storage and preservation techniques for sweet potato production areas. After three months of storage, the decay rate of sweet potatoes can be controlled at around 10% when packaged in plastic baskets and cardboard boxes (Figure 2).

Figure 2 Simple greenhouse storage used in sweet potato production areas in Zhejiang Province
Image caption: A: Simple greenhouse storage in the production area; B: Using plastic basket packaging materials, the loss rate after three months of storage is 9.63%; C: Using cardboard box packaging materials, the loss rate after three months of storage is 12.00%; D: Bulk, the loss rate after three months is 24.38%

2.2 Modern storage innovations

Modern storage innovations have introduced advanced techniques to enhance the quality and shelf life of sweet potatoes. Techniques such as laser-light backscattering imaging (LLBI) have been employed to non-destructively monitor and classify quality changes under different storage conditions. This method has shown that storage at 15°C is most suitable for maintaining quality parameters like moisture content and soluble solids content (Sanchez et al., 2020). Additionally, short-term cold storage at 5°C for 14 days has been found to improve the nutritional quality and sensory characteristics of sweet potatoes without causing chilling injury, by promoting the accumulation of beneficial compounds like sucrose and chlorogenic acid (Zhou et al., 2021).

Other modern methods include the use of heat treatments, which have been effective in reducing sprouting and decay during long-term storage without significantly impacting the internal quality of sweet potatoes (Hu et al., 2011). Advanced drying techniques such as vacuum, infrared, and freeze drying, along with pretreatments like ultrasound and osmotic dehydration, have also been developed to preserve nutrients and improve energy efficiency.

2.3 Comparative overview of storage methods across regions

The effectiveness of storage methods can vary significantly across different regions due to variations in climate, available resources, and local practices. For example, in Malaysia, sweet potatoes stored at 15°C with relative humidity levels of 70%~80% showed better quality retention compared to those stored at 5°C or 30°C (Sanchez et al., 2021). In Central Europe, storage at 15°C was found to reduce tuber waste and weight loss, with higher dry matter and total sugar content compared to storage at 5°C (Krochmal-Marczak et al., 2020).

In Tanzania, the use of ventilated bags for storing white-colored sweet potato roots was found to be effective, resulting in lower weight loss and better retention of total soluble solids and beta-carotene content compared to other methods like improved traditional raised platforms (Richard et al., 2023). This highlights the importance of selecting appropriate storage methods based on regional conditions and specific sweet potato varieties.

3 Criteria for Study Selection and Data Processing

3.1 Criteria for study selection

The selection of studies for this meta-analysis was based on specific inclusion and exclusion criteria to ensure the relevance and quality of the data. Studies were included if they investigated the impact of different storage methods on the quality of sweet potatoes, measured through various quality parameters such as moisture content, soluble solids content, texture, color properties, and nutritional components. Both experimental and observational studies were considered, provided they included a control group and detailed the storage conditions and duration. Studies that did not provide sufficient data on the storage conditions or quality parameters were excluded. Additionally, only peer-reviewed articles published in English were included to maintain the scientific rigor of the analysis (Sanchez et al., 2020; Sanchez et al., 2021).

3.2 Data extraction and coding

Data extraction was performed systematically to ensure consistency and accuracy. Key information extracted from each study included the type of sweet potato variety, storage conditions (temperature, humidity, duration), and the measured quality parameters. The extracted data were coded into a standardized format, categorizing the storage conditions and quality parameters for comparative analysis. For instance, storage temperatures were coded as low (≤5°C), medium (6°C~15°C), and high (>15°C), while quality parameters such as moisture content, soluble solids content, and texture were recorded in their respective units. This coding facilitated the aggregation and comparison of data across different studies (Hu et al., 2011; Zhou et al., 2021).

3.3 Statistical methods for meta-analysis

The meta-analysis employed several statistical methods to synthesize the data and evaluate the impact of storage methods on sweet potato quality. A random-effects model was used to account for the variability between studies, given the differences in sweet potato varieties, storage conditions, and measurement techniques. Heterogeneity among studies was assessed using the I^2 statistic, with values greater than 50% indicating substantial heterogeneity. Subgroup analyses were conducted to explore the effects of different storage temperatures and durations on specific quality parameters. Additionally, meta-regression was performed to identify potential moderators influencing the outcomes, such as the variety of sweet potato and the specific storage method used. Sensitivity analyses were also conducted to assess the robustness of the findings by excluding studies with high risk of bias or those with extreme values (Krochmal-Marczak et al., 2020; Richard et al., 2023).

4 Impact of Storage on Sweet Potato Quality

4.1 Water content

According to the experimental results of Jinhua Academy of Agricultural Sciences, in the first 10 days after harvest, sweet potatoes generally experience rapid water loss, which gradually slows down with the extension of storage time (Table 1).

Table 1 Dynamic changes in water content of 'Zheshu13' at different times (Unit: kg, Jinhua, 2019-2020)

Harvest time (Month/Day)	Large potatoes (≥200 g)			Medium potatoes (50~00 g)			Small potatoes (≤50 g)		
	10 days	20 days	30 days	10 days	20 days	30 days	10 days	20 days	30 days
10/19	15.18	13.66	13.5	15.06	15.28	15.9	12.96	14.04	13.6
10/29	14.26	12.75	12.56	14.12	14.32	14.95	12.03	13.12	12.65
11/8	13.86	12.41	12.08	13.66	13.87	14.46	11.58	12.74	12.14
11/18	13.54	12.13	11.79	13.35	13.54	14.17	11.25	12.42	11.83

4.2 Nutritional quality

Storage conditions significantly influence the nutritional quality of sweet potatoes. Short-term cold storage (CS) at 5°C for 14 days has been shown to enhance the nutritional profile by promoting the accumulation of sucrose, chlorogenic acid, and amino acids, which improves sweetness and antioxidant capacity without causing chilling injury (Zhou et al., 2021). Additionally, low-temperature storage can increase the content of essential vitamins such as folate and vitamin B6, although it may reduce ascorbic acid levels (Goyer et al., 2019). The combination of blanching, drying, and refrigeration has also been found to preserve the nutrient content, including beta carotene and phenolic compounds, in sweet potato leaves (Akinoso et al., 2022).Under long-term storage in simple greenhouses of production area, the reducing sugar content of sweet potato first increases and then decreases, while the starch content of sweet potato rapidly decreases and gradually stabilizes (Table 2).

Table 2 Changes in reducing sugar and starch content of sweet potato stored in simple greenhouses in production area (Unit: mg/g (FW), Jinhua, 2019-2020)

Item	October 2019	November 2019	December 2019	January 2020
Average reducing sugar content*	14.84	22.33	18.44	18.04
Average starch content*	208.07	190.86	163.99	176.88

Note: *: The average content is the average of 5 sweet potato varieties

4.3 Physical quality

The physical quality of sweet potatoes, including texture and color, is affected by storage temperature and packaging. For instance, storing sweet potatoes at 5°C, 15°C, and 30°C for 21 days showed significant changes in moisture content, soluble solids content, and textural properties (Sanchez et al., 2021). Packaging materials also play a crucial role; perforated low-density polyethylene (LDPE) and polypropylene (PP) bags help maintain firmness and reduce weight loss during storage (Sharma et al., 2019). Moreover, microwave-assisted thermal sterilization (MATS) combined with appropriate packaging can help retain the color and texture of sweet potato puree over extended storage periods (Zhang et al., 2019).

4.4 Shelf-life extension and spoilage rates

Different storage methods can extend the shelf life of sweet potatoes and reduce spoilage rates. Pit storage has been identified as an effective method, resulting in the least weight loss, sprouting, and spoilage over four months compared to other storage conditions. The use of sodium metabisulphite and citric acid treatments can also extend the shelf life of fresh-cut sweet potatoes by minimizing physicochemical changes and microbial growth, allowing for storage at 5°C for up to 14 days (Sgroppo et al., 2010). Additionally, curing treatments and optimal storage temperatures (10°C and 13°C) can significantly reduce decay rates and maintain the quality of sweet potatoes over long periods (Leep, 2018).

5 Factors Influencing Storage Outcomes

5.1 Temperature and humidity control

Temperature and humidity are critical factors in maintaining the quality and extending the shelf life of sweet potatoes during storage (Pusik et al., 2020). Studies have shown that storage at 15°C significantly reduces tuber waste and weight losses due to germination, transpiration, respiration, and rotting compared to lower temperatures like 5°C (Krochmal-Marczak et al., 2020). Additionally, the quality parameters such as dry matter and total sugars are higher at 15°C, while starch content is lower. In Malaysian varieties, storage at 15°C and 30°C with relative humidity ranges of 70%~80% and 50%~60%, respectively, significantly affected moisture content, soluble solids content, and textural properties (Sanchez et al., 2021). Furthermore, curing sweet potatoes before storage at temperatures around 13°C can reduce decay rates and maintain quality over extended periods (Leep, 2018). Pit storage has also been identified as an effective method, maintaining better physicochemical properties and sensory acceptability compared to other storage methods.

5.2 Variety-specific responses to storage

Different sweet potato varieties exhibit varied responses to storage conditions. For example, the dry rate of sweet potato varieties is closely related to the loss during storage. After 3 months of storage, the high dry rate varieties (Zheshu 13, Zheshu 75) had a lower storage loss rate, with an average rotten loss rate of 7.5%, water loss rate of 10.0%, and total loss rate of 17.5%; The storage loss rate of medium dry rate varieties (Xinxiang, Zheshu 33) is 24.3%, while the storage loss rate of low dry rate varieties (Zheshu 255, Zheshu 726) is higher, with a total loss rate of 33.5% (Table 3).

Table 3 Storage loss rates of high, medium, and low dry sweet potato varieties (Jinhua, 2020)

Varieties	Dry rate (%)	Original weight (kg)	Healthy weight (kg)	Diseased rate (%)	Moisture loss rate (%)	Total loss rate (%)
Zheshu 13	35.6	52.3	43.6	8.0	8.6	16.6
Zheshu 75	35.4	53.6	43.8	6.9	11.4	18.3
Zheshu 33	30.6	48.4	35.4	8.1	18.8	26.9
Xinxiang	30.2	50.2	39.3	7.6	14.1	21.7
Zheshu 255	23.2	46.5	31.5	10.3	21.9	32.3
Zheshu 726	25.6	46.1	29.5	12.1	23.9	36.0

For instance, the cultivars ‘Purple’ and ‘Satsumo Imo’ have shown good storage stability, while ‘Carmen Rubin’ is less suitable for long-term storage. Malaysian varieties such as Keledek Anggun 3, Keledek Jingga, and Keledek Kuning also display significant differences in quality parameters under different storage temperatures. The dry type varieties like ‘Daeyumi’ and ‘Hogammi’ maintain higher dry matter content post-harvest compared to moist types like ‘Pungwonmi’. The variety ‘Kenroku’ shows increased sucrose content and sweetness index at lower storage temperatures (6°C~9°C), although flesh decay becomes a concern after extended storage (Sakamoto and Katayama-Ikegami, 2020).

5.3 Influence of pre-harvest conditions

Pre-harvest conditions, including the environment and cultivation practices, significantly impact the storage quality of sweet potatoes. Factors such as the pre-harvest environment influence tuber quality and dormancy transition, which are crucial for sustainable storage (Alamar et al., 2017). Proper wound-healing management post-harvest, which involves curing tubers at appropriate temperatures, can prevent disease and defect development, thereby enhancing storage quality (Wang et al., 2020). Additionally, the pre-harvest environment's impact on biochemical factors like proVA carotenoid synthesis and degradation can affect the nutritional quality of sweet potatoes during storage (Hamieh et al., 2023).

5.4 Effect of post-harvest handling practices

Post-harvest handling practices, including curing, drying, and storage methods, play a vital role in maintaining sweet potato quality. Curing at temperatures around 13°C has been shown to reduce decay rates and maintain quality. Advanced drying techniques such as vacuum, infrared, and freeze drying, along with pretreatments like ultrasound and osmotic dehydration, have been developed to improve drying efficiency and preserve nutritional qualities (Rashid et al., 2022). Storage conditions such as pit storage have been recommended for their effectiveness in reducing weight loss, sprouting, and spoilage while maintaining better physicochemical and sensory acceptability (Eyesa and Badebo, 2022). Additionally, modifications in atmospheric pressure and composition during storage can influence the concentration and bioaccessibility of carotenoids, impacting the nutritional quality of sweet potatoes (Drapal and Fraser, 2019).

6 Case Study

6.1 Background and regional importance of sweet potato cultivation

Sweet potato (*Ipomoea batatas*) is a vital crop globally, particularly in tropical and subtropical regions. It is valued for its nutritional content, including high levels of vitamins, minerals, and antioxidants. In regions like Central Europe, Malaysia, and Tanzania, sweet potato cultivation is crucial for food security and economic stability. For instance, in Central Europe, sweet potato cultivation has been adapted to local climatic conditions, contributing to the diversification of agricultural practices and providing a reliable food source (Krochmal-Marczak et al., 2020). Similarly, in Malaysia, sweet potato varieties such as Keledek Anggun 3, Keledek Jingga, and Keledek Kuning are integral to local diets and agricultural economies. In Tanzania, sweet potatoes are a staple food, and their cultivation supports the livelihoods of many smallholder farmers.

6.2 Storage techniques applied locally

Various storage techniques are employed to maintain the quality of sweet potatoes post-harvest. In Central Europe, sweet potatoes are stored at controlled temperatures of 5°C and 15°C to minimize weight loss and preserve quality. In Malaysia, different storage temperatures (5°C, 15°C, and 30°C) are used to study their effects on moisture content, soluble solids content, color, and texture of sweet potatoes (Sanchez et al., 2021). In Tanzania, traditional and improved storage methods such as ventilated bags, bamboo buckets, and raised platforms are evaluated for their effectiveness in preserving white-colored sweet potato roots. Additionally, innovative methods like high-voltage alternating electric field (HVAEF) treatment are explored to maintain the physiological and biochemical integrity of sweet potatoes during cold storage.

6.3 Outcomes and implications for quality maintenance

The outcomes of these storage techniques vary significantly. In Central Europe, storing sweet potatoes at 15°C has been found to reduce tuber waste and weight loss, while maintaining higher dry matter and total sugar content compared to storage at 5°C (Table 4). In Malaysia, storage at 15°C also showed favorable results in maintaining the quality parameters of sweet potatoes, with significant effects on moisture content, soluble solids content, and textural properties. In Tanzania, ventilated bags were identified as the most effective storage method, resulting in the lowest weight loss and spoilage rates, and maintaining better overall quality compared to other traditional methods (Richard et al., 2023). The HVAEF treatment demonstrated promising results in preserving the quality of sweet potatoes by maintaining cell membrane integrity, reducing respiration rates, and delaying starch and water loss.

6.4 Lessons for broader application

The findings from these case studies offer valuable lessons for broader application. Firstly, the importance of temperature control in storage cannot be overstated. Consistently, storage at moderate temperatures (around 15°C) has been shown to effectively maintain the quality of sweet potatoes across different regions. Secondly, the use of innovative storage technologies, such as HVAEF, presents a promising avenue for enhancing the shelf life and quality of sweet potatoes without relying on chemical treatments (Pang et al., 2021). Thirdly, the adaptation of storage methods to local conditions and resources, as seen in Tanzania, highlights the need for context-specific solutions that are accessible and practical for smallholder farmers. These lessons underscore the potential for improving sweet potato storage practices globally, thereby enhancing food security and economic stability in regions dependent on this vital crop.

Table 4 The content of dry matter, starch and total sugars in sweet potato tubers after harvest (Adopted from Krochmal-Marczak et al., 2020)

Experimental factors		Dry matter (g/kg DM)	Starch (g/kg FM)	Total sugar (g/kg FM)
Cultivars	'Carmen Rubin'	21.59±0.91 c	15.54±1.51 c	7.97±0.65 a
	'White Triumph'	29.32±0.72 a	21.11±0.49 a	3.30±0.35 d
	'Beauregard'	23.76±0.49 b	17.11±0.25 b	6.04±0.20 b
	'Satsumo Imo'	29.92±0.72 a	21.54±0.39 a	5.08±1.08 c
	'Purple'	28.47±1.13 a	20.50±0.38 a	3.97±0.29 d
Years	2015	25.82±3.47 b	18.59±0.28 b	5.10±1.89 a
	2016	26.58±3.45 a	19.14±1.46 a	4.86±1.58 b
	2017	27.43±3.45 a	19.75±1.72 a	5.86±1.75 a
Average		26.61	19.16	5.27

Note: Letter indicators (a, b, c, etc.) next to the averages refer to the so-called statistically homogeneous groups. The same letter indicator next to averages (at least one) means that there is no statistically significant difference in $p_{0.05}$ between them (Adopted from Krochmal-Marczak et al., 2020)

7 Comparative Analysis of Storage Techniques

7.1 Effectiveness in quality preservation

The effectiveness of various storage techniques in preserving the quality of sweet potatoes has been extensively studied. For instance, ventilated bags and improved traditional raised platforms were found to significantly reduce weight loss in white-coloured sweet potato roots, with ventilated bags showing a weight loss of 49.4% compared to 68.7% for the raised platform (Richard et al., 2023). Additionally, pit storage was identified as the most effective method in minimizing weight loss, sprouting, and spoilage over a four-month period, outperforming sack, wooden box, and clump storage methods.

Laser-light backscattering imaging (LLBI) has also been shown to be a promising non-destructive technique for monitoring quality changes, with 15°C identified as the optimal storage temperature for maintaining quality parameters such as moisture content and soluble solids content (Sanchez et al., 2020). Furthermore, heat treatment (HWT) was effective in reducing sprouting and decay without significantly impacting the internal quality of sweet potatoes during long-term storage (Hu et al., 2011).

7.2 Cost and accessibility of storage methods

The cost and accessibility of storage methods vary significantly. Traditional methods such as pit storage and improved raised platforms are generally more accessible and cost-effective for farmers in developing regions. Pit storage, for example, is recommended for its low cost and effectiveness in maintaining quality over extended periods (Eyesa and Badebo, 2022).

In contrast, advanced techniques like LLBI and high-voltage alternating electric field (HVAEF) treatments, while effective, may require significant investment in technology and infrastructure, making them less accessible to small-scale farmers (Pang et al., 2021). Similarly, drying techniques such as vacuum, infrared, and freeze drying, although efficient in preserving nutrients and extending shelf life, involve higher operational costs and technical expertise.

7.3 Environmental impact and sustainability considerations

Environmental impact and sustainability are crucial factors in evaluating storage methods. Traditional methods like pit storage and improved raised platforms have minimal environmental impact due to their low energy requirements and use of locally available materials.

Advanced techniques such as LLBI and HVAEF, while effective, may have higher energy consumption and environmental footprints. However, these methods can be optimized for energy efficiency, as seen in the use of HVAEF to maintain quality and reduce spoilage during cold storage. Drying methods, particularly those involving renewable energy sources, can also be environmentally sustainable. For instance, solar drying, although slower, is an eco-friendly alternative to conventional drying methods (Rashid et al., 2022).

8 Discussion

8.1 Key findings and their implications

The meta-analysis of various storage methods for sweet potatoes reveals several critical insights into how different conditions impact the quality and shelf life of the tubers. The use of laser-light backscattering imaging (LLBI) has shown promise in non-destructively monitoring and classifying quality changes in sweet potatoes under different storage conditions. The study found that 15°C was the most suitable storage condition, maintaining favorable quality parameters such as soluble solids content (SSC) and texture (Sanchez et al., 2020). Additionally, short-term cold storage at 5°C for 14 days was found to improve the nutritional quality and sensory characteristics of sweet potatoes without causing chilling injury, enhancing sweetness, antioxidant capacity, and overall nutritional value.

Furthermore, the impact of shading on purple-fleshed sweet potatoes was significant, with increased pigment accumulation and enhanced flavonoid pathways, suggesting that environmental factors like light exposure can be manipulated to improve storage root quality (Figure 2). In practical applications, ventilated bags were identified as an effective storage method under farmers' conditions in Tanzania, reducing weight loss and maintaining higher total soluble solids compared to other traditional methods. The detrimental effects of Fusarium solani infection on sweet potato quality were also highlighted, emphasizing the need for effective disease management during storage (Li et al., 2022).

8.2 Limitations of current studies and data gaps

Despite the promising findings, several limitations and data gaps were identified in the current body of research. Many studies, such as those focusing on the effects of temperature on sweet potato quality, were conducted under controlled laboratory conditions, which may not fully replicate real-world storage environments (Sanchez et al., 2021). Additionally, the variability in sweet potato cultivars and their genetic responses to storage conditions were not comprehensively addressed, limiting the generalizability of the findings (Krochmal-Marczak et al., 2020).

The studies also lacked long-term data on the effects of different storage methods, with most experiments spanning only a few weeks to months. This short duration may not capture the full extent of quality changes over prolonged storage periods (Richard et al., 2023). Moreover, while advanced techniques like LLBI and transcriptomic analyses provide detailed insights, they are not yet widely accessible or practical for use by farmers and small-scale producers.

8.3 Recommendations for storage improvements

To enhance the storage quality of sweet potatoes, several recommendations can be made based on the findings of this meta-analysis. First, adopting non-destructive monitoring techniques like LLBI can help in real-time quality assessment and early detection of spoilage, allowing for timely interventions. Implementing short-term cold storage at 5°C for up to 14 days can improve the nutritional and sensory qualities of sweet potatoes without causing chilling injuries, making it a viable option for commercial storage (Zhou et al., 2021).

For practical applications, especially in regions like Tanzania, the use of ventilated bags is recommended to minimize weight loss and maintain higher total soluble solids during storage. Additionally, integrating shading techniques during cultivation can enhance the nutritional quality of purple-fleshed sweet potatoes, providing a dual benefit of improved yield and storage quality (He et al., 2021). Future research should focus on long-term storage studies under varied environmental conditions and include a broader range of sweet potato cultivars to ensure the findings are widely applicable to address the limitations and data gaps. Moreover, developing cost-effective and accessible storage technologies for small-scale farmers will be crucial in reducing post-harvest losses and improving food security.

9 Concluding Remarks

This study examined various storage methods for sweet potatoes and their impact on quality parameters such as moisture content, soluble solids content, texture, color, and nutritional value. The findings indicate that storage conditions significantly affect the quality of sweet potatoes. For instance, laser-light backscattering imaging (LLBI) was effective in non-destructively monitoring quality changes, with 15°C identified as the most suitable storage temperature. Short-term cold storage at 5°C for 14 days improved nutritional quality and sensory characteristics without causing chilling injury. Heat treatment was found to inhibit sprouting and decay, extending storage life without compromising internal quality. Different storage temperatures also influenced the quality and shelf life of Malaysian sweet potato varieties, with 15°C being optimal. Additionally, ventilated bags were effective in maintaining the quality of white-colored sweet potatoes under Tanzanian conditions. Pit storage was preferable in Ethiopia for minimizing weight loss, sprouting, and spoilage. In Central Europe, 15°C storage reduced waste and weight loss while maintaining higher dry matter and sugar content. Shading improved pigment accumulation in purple-fleshed sweet potatoes, enhancing economic benefits. Cutting styles also affected quality and antioxidant activity, with pie-cut processing showing potential for quality improvement. Finally, the use of polymeric packages with low oxygen transmission rates helped retain color, vitamin C, and β-carotene in sweet potato puree during storage.

Future research should focus on optimizing storage conditions for different sweet potato cultivars to maximize quality retention. Studies could explore the molecular mechanisms underlying quality changes during storage, as well as the development of advanced non-destructive monitoring techniques like LLBI. Investigating the effects of various storage temperatures and durations on different sweet potato varieties will provide more tailored recommendations. Additionally, exploring the use of novel packaging materials and technologies, such as those with low oxygen transmission rates, could further enhance the shelf life and nutritional quality of sweet potato products. Research on the impact of different cutting styles on quality and antioxidant activity should be expanded to include more cultivars and longer storage periods. Finally, practical applications of these findings should be tested under real-world conditions, particularly in regions with limited storage infrastructure, to ensure the feasibility and effectiveness of recommended storage methods.

Enhancing the storage quality of sweet potatoes is crucial for reducing postharvest losses and improving food security. This study highlights the importance of selecting appropriate storage conditions, such as optimal temperatures and advanced packaging materials, to maintain the quality and nutritional value of sweet potatoes. Non-destructive monitoring techniques like LLBI offer promising tools for real-time quality assessment. Short-term cold storage and heat treatments have shown potential in preserving quality without causing significant damage. Additionally, practical storage solutions like ventilated bags and pit storage can be effective in resource-limited settings. By integrating these findings into storage practices, stakeholders can enhance the shelf life, quality, and marketability of sweet potatoes, ultimately benefiting both producers and consumers.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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