Evaluation of the effectiveness of Low Energy Cooling Chamber (LECC), cold room, and misting chamber on storage life and quality of the vegetables (amaranth, nightshade, tomatoes, and African eggplant) in Tanzania.

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Abstract

In warm climates, inefficiencies in post-harvest management of fresh produce lead to significant spoilage and waste, affecting food security and farmers' livelihoods. This study evaluated three storage methods, Low Energy Cooling Chamber (LECC), misting chamber, and cold room, against ambient conditions to assess their effectiveness in extending shelf life and preserving the quality of fresh produce. The focus was on weight loss, colour changes, and storage temperature, repeated twice for consistency. The cold room was most effective, extending the shelf life of tomatoes to two weeks compared to three days in ambient conditions. The misting chamber and LECC extended tomato shelf life to five and seven days, respectively. Leafy vegetables, however, experienced significant weight loss and colour changes by the third and fourth day in the misting chamber and LECC, leading to their disposal. In the cold room, leafy vegetables showed no significant colour changes but suffered weight reduction and leaf abscission by the fourth day. The study concluded that in Arusha's warm and humid climate, fruit vegetables like tomatoes had prolonged shelf life in the cold room (two weeks), LECC (seven days), and misting chamber (five days). Leafy vegetables' shelf life remained short across all methods, at three to four days. Recommendations include improving LECC design, enhancing water quality for LECC and misting chambers, and ensuring cold room temperatures reach a minimum of 5°C. Future studies should investigate these methods in cooler, dryer ambient conditions for better versatility insights.

Introduction

In Tanzania, post-harvest vegetable losses significantly impact food security and economic stability (Bisheko & Rejikumar, 2024). Effective storage solutions are crucial for preserving produce quality (Palumbo et al., 2022). High temperature and humidity can affect the efficacy of storage technologies (Al-Dairi et al., 2023; Alemu, 2023). This study aims to evaluate three innovative cooling technologies, Low Energy Cooling Chamber (LECC), cold room, and misting chamber in Arusha, northern Tanzania. It focuses on studying the storage life and quality of amaranth, nightshade, tomatoes, and African eggplant, using appropriate locally adapted technologies (Pace, 2021).

Methodology

The effectiveness of three storage methods: Low Energy Cooling Chamber (LECC), misting chamber, and cold room were studied for extending vegetable shelf life with storage temperature, weight loss, and colour change measured. Experiments were repeated twice for consistency, using ambient conditions as a control.

Located in northern Tanzania, Arusha experiences a tropical savanna climate with average maximum temperatures of 22.0°C to 29.1°C and minimum temperatures of 12.7°C to 16.6°C. Relative humidity ranges from 60-90% in the morning to 40-70% in the afternoon, with peak rainfall in March and April.

Samples were collected from two local markets within 10 hours of harvest. Leafy and fruit vegetables were bundled and labelled by storage method, type, and experiment number. Vegetables were weighed with a high-precision balance, and colour was measured using a Nix Pro 2 colourimeter, including lightness (L*), greenness (a*), and yellowness (b*). Data collection continued daily until spoilage. The experiment had three treatments: 1) Cold Room: An insulated room with an air conditioner which was connected to a CoolBot, this allowed the room to attain lower temperatures than normally possible with an air conditioner alone; 2) Misting Chamber: A net-walled frame with a metallic structure and a drip system to elevate humidity; and 3) LECC: A modified Zero Energy Cooling Chamber, as described by (Kamal et al., 2018), and Mishra et al., (2020), with low energy consumption, using a light vacuum to extract out warm air. These methods were compared to ambient conditions, with the cold room being the most effective, followed by the LECC and misting chamber, as shown in Figure 1 below.

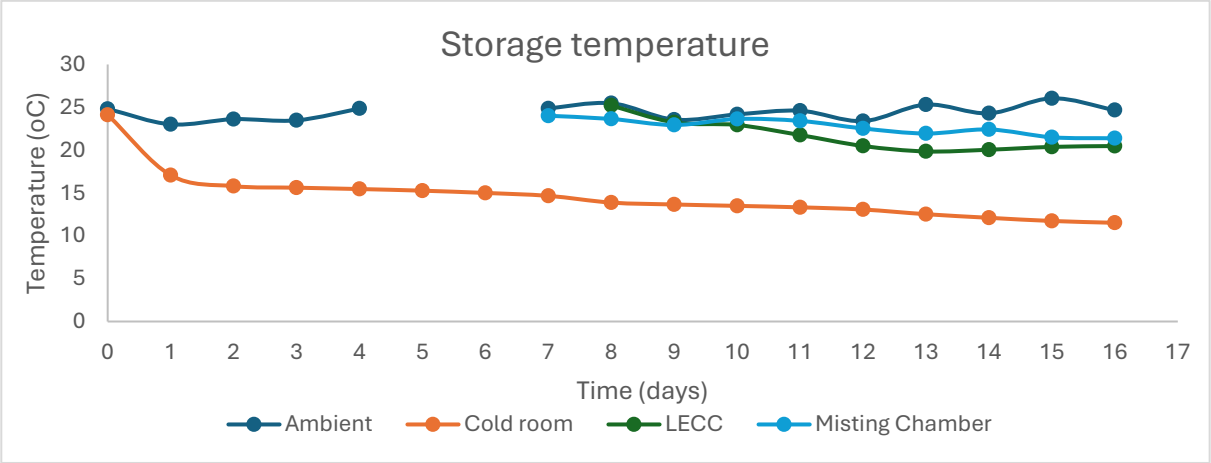

Figure 1: Average daily storage temperatures of the 3 storage methods compared with ambient conditions.

The average ambient temperature fluctuated between 23-25°C over 16 days. The cold room started at 24°C, dropped sharply to 10°C by day 2, and remained steady at 10°C. LECC began at 24°C, decreased to around 20°C by day 1, and fluctuated between 19-20°C. The misting chamber started at 24°C, dropped to 20°C by day 1, and fluctuated between 19-22°C over 8 days.

Results

The cold room was the most effective, significantly extending the shelf life of tomatoes to two weeks, compared to three days under ambient conditions. The LECC and misting chamber extended tomato shelf life to seven and five days, respectively. For leafy vegetables, the cold room delayed weight reduction and leaf abscission until the fourth day, but they experienced significant weight loss (Figure 2) and colour changes (green to yellow) in the misting chamber and LECC by the third and fourth day, leading to their disposal.

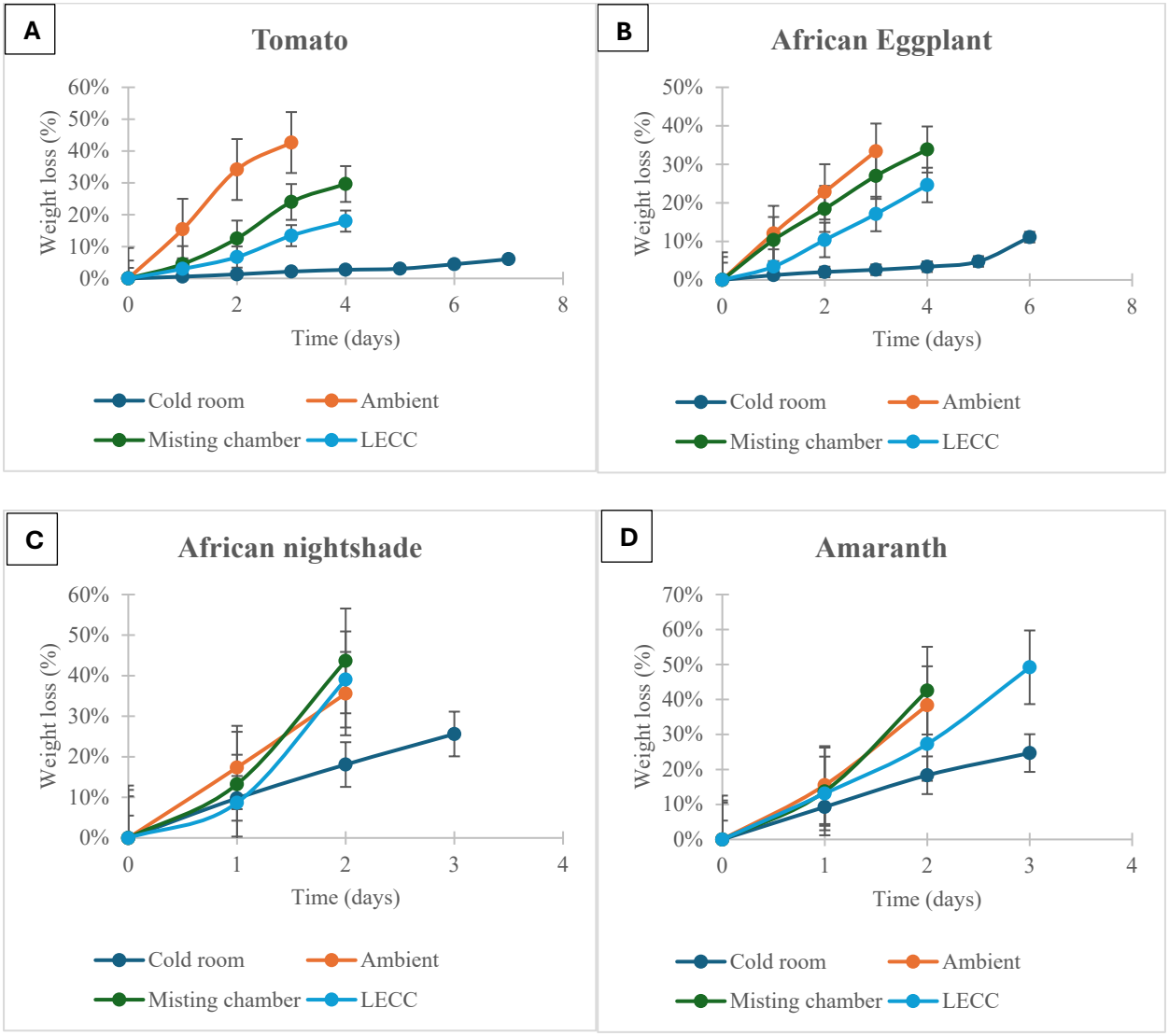

Figure 2: Weight loss (%) of four vegetables: A (tomatoes), B (eggplant), C (amaranth), and D (nightshade). Tomatoes and eggplant stored in the ambient have demonstrated high weight loss, while the cold room exhibited low weight loss and a more extended shelf-life (Figure 2A). The leafy vegetables (Figures 2C and 2D) demonstrated a slightly higher weight loss (%) on day 2 in the misting chamber compared to the ambient condition, however, the cold room demonstrated low weight loss (%).

The cold room maintained a steady temperature of around 10°C after an initial drop from 24°C. The LECC fluctuated between 19°C and 20°C, while the misting chamber varied between 19°C and 22°C. However,

these results were impacted by rain on days 2, 5, 8, and 12, as the weather was humid (relative humidity at 97%, 92%, 95%, and 98% respectively). The water quality was also poor (with algae), and the supply system (drip lines) experienced unexpected blockages, mainly at night. These factors limited the performance of both the LECC and the misting chamber.

Conclusion

The study concluded that in Arusha's warm and humid climate, the cold room is the most effective for extending the shelf life of fruit and vegetables, especially tomatoes. Leafy vegetables had a shorter shelf life across all methods. Recommendations include improving the LECC design, enhancing water quality with filters, for the LECC and misting chambers, and ensuring the cold room reaches a minimum temperature of 5°C. Future studies should explore appropriate technical design and water supply systems to improve the performance of the storage methods assessed in this study while investigating the performance of these methods in cooler, dryer ambient conditions to better understand their versatility. In addition, further studies should include the nutritional variables in assessing the quality changes of the vegetables.

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