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Incentives and disincentives of adopting wooden crate paper lining: a field experiment with traders and retailers in Tanzania

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Key Findings / Background

- Tomato value chains have high postharvest losses, making the crop expensive to consumers
- This study shows that the use of paper lining in tomato crates reduces postharvest losses
- The high cost of paper lining is a disincentive to wider adoption of the technology
- While value chain actors want to reduce postharvest losses, more evidence is needed on what works best

Introduction

Tanzania's fruit and vegetable sector has grown tremendously, with output in tons increasing 4.1-fold from 1990 to 2020 (Reardon et al., 2024). Tomatoes are the most important vegetable grown in most regions of the country in terms of acreage and production value. Most production happens in clusters of farms across the country, including Morogoro, Dodoma, the southern highlands of Iringa, and the northern highlands of Arusha and Kilimanjaro. The tomato trade is characterized by long-distance supply chains from rural areas to cities and across borders. While the long supply chains make tomatoes widely available across the country, postharvest losses are a significant challenge. Studies have reported tomato losses of 20 to 50 percent (e.g. Abbot et al., 2023). Variety, harvest practices, packaging, handling, transportation, and marketing determine postharvest losses. The common practice in Tanzania and other countries in sub-Saharan Africa is to use wooden crates with rough interiors that damage the produce during packing and transport. High losses contribute to sharp price fluctuations and regular shortages on the market, adversely affect profit margins, and reduce affordability and access to this important vegetable, especially for low-income households.

The paper lining of wooden crates is a simple packaging innovation that is recommended for reducing the waste and spoilage of tomatoes. For instance, Dari et al. (2018) estimated that a paper-lined 50 kg wooden crate reduces losses by 25% in Ghana. However, the uptake of paper-lined crates is minimal in Tanzania despite the low cost of the technology. Kamrath et al. (2018) showed that collectors are reluctant to adopt the technology because they believe it cannot be used during the rainy season, they lack awareness and knowledge of the technology, they lack evidence of success, and they fear that retailers cannot inspect the product before buying. Retailers, though, showed great interest in paper lining. They evaluated tomato quality in a paper-lined wooden crate as higher than in standard wooden crates, even if they could not inspect the entire crate. There is a need for more evidence on using paper lining for postharvest loss reduction.

We employed a field experiment to assess the effectiveness of paper lining in loss reduction and identified incentives and

disincentives for adopting it. Unlike most studies that perform a controlled experiment with researchers buying and transporting products in a vehicle or assessing perceptions among value chain actors, our study is a real-world experiment in an uncontrolled environment. Traders and retailers were given paper liners for use during transportation, and their opinions were recorded. Scaling of this technology is planned based on its performance and review from the pilot group regarding its potential to reduce losses in vegetable trading.

This study is part of the CGIAR Initiative on Fruit and Vegetables for Sustainable Healthy Diets (FRESH). FRESH uses an end-to-end approach to increase fruit and vegetable intake and improve diet quality, nutrition, and health while improving livelihoods, empowering women and youth, and mitigating environmental impacts. In Tanzania, FRESH is implemented in Arusha and Kilimanjaro regions.

Methods

Study site

This study was conducted in Arusha, Tanzania. We engaged with Multipurpose Group, one of the largest group of traders in the Kilombero market, with about 80 tomato traders. The Group has a monthly turnover of about 900 tonnes of tomatoes. The Group provides services such as saving and credit, exchanging business information such as area of sourcing, controlling tomato selling, and influencing market price. Collective selling is not always done as each trader organizes their collection, transport, and produce delivery. We selected this Group because it is large enough to influence the trading of tomatoes in Arusha and beyond. We selected four traders from Multipurpose Group that procure tomatoes from Ngarenanyuki and Nkure, which are FRESH project sites. Researchers approached retailers who bought produce from the selected traders and asked them to participate in the study.

The intervention

Two packaging materials were compared: the standard and paper-lined wooden crate (**Fig. 1**). Paper liners were provided for free. The project paid for the tomatoes used in the experiment. It was difficult to control for tomato varieties as traders procured from farmers who grew different varieties.

Figure 1: Standard crate and crate (left) with paper lining (right)
Source: Authors

Study design

Researchers used the load tracking method to evaluate weight and to visually inspect product quality for sample crates as the produce moved from farm to retail. It was observed how the product was handled, packaged, transported, and offloaded.

At the farm level traders bought the tomatoes and packaged them into standard wooden crates. Before packing we randomly selected two crates from the consignment: i) one for control (standard wooden crate) and ii) one for treatment (paper lining). The two crates were labeled with colored ribbons and loaded in the truck with other standard crates from the farms to the Kilombero market using regular routes, and transport means. The ribbons helped to retrieve the sample crates for the assessment quickly.

Once the produce reached the market, researchers selected traders interested in the study. The retailers, most of whom bought one standard crate, were also asked to take one paper-lined crate paid for by the project. The retailers then transported the two crates while the researchers monitored the product movement from market to retail outlet.

After the experiment, study participants and other actors, including those involved with packaging and transportation, attended a one-day feedback workshop in which the findings of the paper-lined technology were presented, and the experiences of using the technology were shared. The workshop was intended to validate the findings, stimulate discussions on using paper-lining, and create awareness. Researchers assessed the potential for technology uptake based on the feedback and discussion.

Data collection

We collected data at the farm gate by weighing the selected sample and sorting and grading the tomatoes using a quality grading scale (**Fig. 2**). The number and weight of tomatoes of different grades were recorded.

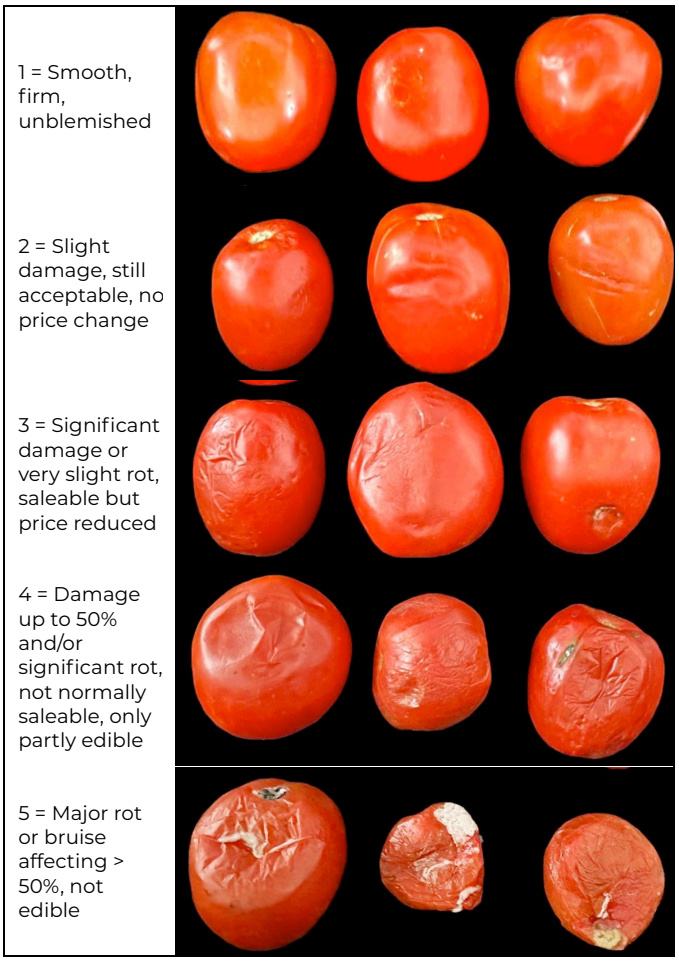

Figure 2: Tomato quality grading scale
Source: Authors

Tomatoes were again weighed, and quality was recorded at the retail outlet. The postharvest loss assessment was followed by a survey that collected information on the basic characteristics and selling prices of retail outlets. Qualitative questions were administered to understand the incentives and disincentives of using paper liners. Researchers also observed buyers' reactions and recorded their opinions on paper-lined crates. Photos and short video clips taken during the exercise provided additional data.

For the economic loss calculation, the value was determined by using retail prices for the different qualities. This was collected at retail level and used as a proxy for the value of the boxes at farm level and compared to the retail level for the different quality grades.

A validation was organized shortly after the pilot to discuss results with the traders and retailers involved.

This experimental study was approved by WorldVeg's Institutional Biosafety and Research Ethics Committee (IBREC) under the registration number 2024-009.

Results

Tomato marketing practices

Tomato harvesting is done manually, typically between 8 am and 3 pm. Most respondents indicated that tomatoes are harvested at maturity, i.e., when "red or mature green". When market supplies are low, immature tomatoes are sometimes included. Women hired by the traders mostly do the harvesting and transport the tomatoes in buckets to packing and sorting sites, which are typically few meters from the farms. The harvest is hand-sorted based on quality and size. The farm has no storage or cooling facilities, but efforts are made to sort and pack in a cooler environment, typically in the shade.

After sorting, tomatoes are manually packed, one by one, in wooden crates. The crates are

struck on the
ground to ensure they are well-filled, which increases the likelihood of damage. More tomatoes are packed on top using carton board tied with ropes around the crate, locally known as "*rumbesa*." Rumbesa has become a tradition, and no trader will purchase a crate that is not topped in this manner.

When ready for transport, tomato crates are manually loaded on a truck by casual workers who carry the crates on their shoulders. The trucks then transport the crates to wholesale markets in various towns and cities or other countries. Trucks mostly arrive at the wholesale market at 6 am. Upon arrival at the wholesale market, the produce is manually offloaded by workers carrying crates on their shoulders. No further sorting is done. Crates are then sold to retailers.

The traders try to sell everything on the same day due to a lack of storage facilities. Retailers bring the crates to their outlets using various means, including motorcycles, tuktuks, and public buses. At their selling outlets which are mainly shops, or kiosks, retailers open the crates and sort the produce by quality. Retailers clean tomatoes with a damp cloth before displaying them. There is no cooling of the produce. The retail price varies by grade and other factors like tomato variety, market supply and demand, and time of the day – with higher prices in the morning.

Delays frequently occur at various stages of the supply chain. During harvesting, the manual nature of the work results in prolonged periods of filling a bucket. Similarly, packing is time-consuming as the produce is sorted and graded by hand.

Additional delays arise while waiting for a truck to arrive. The truck is only loaded once there are enough crates to fill it. Due to the small-scale nature of the farms, traders collect produce from multiple farms. Poor road conditions in remote areas increase transportation time.

Postharvest losses were reported to occur along the value chain during sorting, packaging, and transportation. One farmer, for instance, stated that rotting and damage are common causes of tomato losses. During harvest, damaged produce is discarded at the farm.

The Rumbesa system has become a tradition and no trader will purchase a crate that is not topped in this manner.

Local quality grading

The study used a standard quality grading scale developed by the FRESH project for Tanzania. However, we noted that the local community has a quality grading system based on size and ripeness. The local grading quality criteria change along the value chain. At farmgate, the criteria are: grade 1 - red ripe and big, grade 2 - mature green and big, and grade 3 - small size. The price per crate of grades 1 and 2 is the same, while that of grade 3 is lower (often about half). At the market level, the tomatoes are graded into two categories: grade 1 - red ripe or mature green, big, and grade 2 - small. The price of grade 1 is double that of grade 2. Three grades are used at the retail level: grade 1 -

large with no or slight damage, grade 2 - medium size or considerable damage, and grade 3 - small size. Sometimes, grade 4 is added for significantly damaged tomatoes.

Reduction of (economic) losses

Economic losses were determined using the standard quality grading system and prices at retail level reported during data collection.

The findings show that using paper-lining of wooden crates improved the quality of tomatoes (**Fig. 3**). This quality improvement attracted more customers and allowed traders to sell more tomatoes at higher prices. The measured weight of the tomatoes from farm to market remained equal at 60 kg per crate throughout the experiment due to the short distance from farm to market.

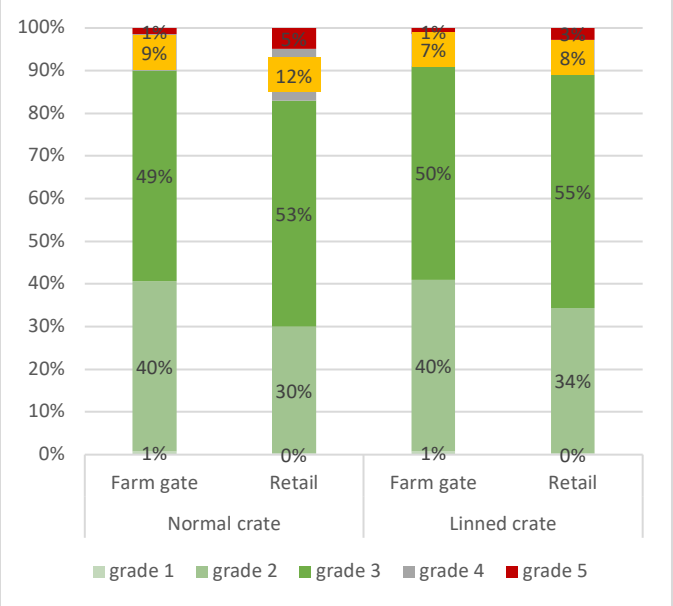

Figure 3: Quality grade at farmgate and retail levels for regular and paper-lined wooden crates, in percentage of total weight

Source: Authors using data from the pilot experiment, 2024.

The economic benefits of the intervention demonstrated positive effects (**Table 1**). Using paper-lined crates resulted in a higher value retained at retail level compared to normal cates (91% compared 87%) due to beter preservation of the tomatoes. In addition, the economic loss at retail level (USD 1.76 per crate) compared to regular wooden crates (USD 3.10) is lower. Participants reported higher revenue from paper-lined crates, which was attributed to better product quality.

However, the overall additional financial value was limited as the cost of adding a paper lining to a crate is USD 0.48.

Table 1: Calculated economic effects (USD)

	Normal crate (n=4)	Paper-lined crate (n=4)
Average value at the farm gate (A), calculated at retail prices	23.62	23.98
Average value at retail (B), calculated at retail prices	20.55	21.92
Calculated value of economic loss (A-B)	3.10	1.76

Source: Authors own using data from the pilot experiment, 2024.

Limitations

Before the experiment, most traders and retailers indicated they were unaware of paper lining. However, they appreciate that paper lining can reduce postharvest losses during transport. During the validation exercise, key issues raised included:

- Paper availability and use: retailers and traders are worried about the cost of the liners and where to buy them. They also wanted more training to understand the technology, including how many paper liners to use, how to punch the holes, etc.
- Reliability of paper liners: participants indicated that the paper lining technology may not work well during the rainy season. They also worried that paper liners may reduce air ventilation and increase temperature. This would need to be studied, especially in areas with high humidity, like Dar es Salaam.

- Packaging: the paper liners block the buyers from inspecting the packed produce. It is a common practice in Tanzania for buyers to visually inspect the sides of the crate to determine the quality of the tomatoes. Customers are unaware of the paper-lining and may hesitate to purchase paper-lined crates.
- The pilot study has small sample size. This limits the generalizability of findings and requires additional research.

Conclusions

Paper lining of wooden crates reduces postharvest losses in the tomato value chain. The calculations show modest economic benefits. Participants appreciated the introduction of new technology.

Way forward

The intervention shows the potential for scalable benefits with broader implementation and longer-term support, however further research is needed to test the effect of paper lining under various conditions (e.g. further away from the market). So, additional experiments on paper lining with different traders are needed to provide more evidence of the feasibility of the technology. Exploring other technologies, such as plastic crates, as an alternative for postharvest loss reduction is also recommended and is perceived by the traders involved as more promising.

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About FRESH

The CGIAR Research Initiative on Fruit and Vegetables for Sustainable Healthy Diets (FRESH) aims to use an end-to-end approach to increase fruit and vegetable intake and in turn improve diet quality, nutrition and health outcomes while also improving livelihoods, empowering women and youth and mitigating negative environmental impacts.

PRIMARY IMPACT AREA:

Nutrition, health & food security