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Adewale Ogunlade
 Department of Agricultural
 and Food Engineering, Federal
 University of Agriculture,
 Abeokuta, Ogun State, Nigeria

Folake Adeyemi
 Department of Agricultural
 and Food Engineering, Federal
 University of Agriculture,
 Abeokuta, Ogun State, Nigeria

Assessment of post-harvest losses in tomato supply chain from farm gate to consumer

Adewale Ogunlade and Folake Adeyemi

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Abstract

Nigeria is Africa's largest tomato producer, yet losses between the field and the consumer's kitchen can exceed a quarter of the harvested volume. This research quantified post-harvest losses at each stage of the tomato supply chain harvesting, sorting, transportation, wholesale marketing, retailing, and final consumption in Abeokuta district, Ogun State. A survey-based approach combined with physical sampling was applied to 30 supply chains over the wet and dry seasons of 2022-2023. Cumulative losses averaged 26.4 %, with the transport segment contributing the single largest share (6.6 %). Mechanical damage was the leading cause at farm and transport stages, while pathological infection dominated at wholesale and retail levels. Losses correlated positively with ambient temperature during transit ($r = 0.83, p < 0.01$). The findings point to targeted interventions ventilated crates, pre-cooling, and shorter marketing channels as the most promising avenues for reducing waste in Ogun State's tomato value chain.

Keywords: Post-harvest losses, tomato, supply chain, loss assessment, fresh produce handling, transport losses, mechanical damage, tropical horticulture

Introduction

As far back as the 1980s, the Nigerian Institute of Food Science and Technology flagged post-harvest losses in vegetables as one of the country's most avoidable forms of food waste, yet four decades later the problem persists at remarkably similar magnitudes ^[1]. Tomato (*Solanum lycopersicum* L.) is especially vulnerable because its thin skin, high moisture content, and active respiration rate make it prone to mechanical injury and rapid microbial colonisation once damaged ^[2].

National estimates place tomato post-harvest losses at 12-30 %, depending on the region and season ^[3]. But these aggregated numbers mask the fact that losses accumulate unevenly across supply chain nodes. A study in Plateau State reported 8 % loss at the farm level alone ^[4], while a parallel assessment in Kaduna State attributed 11 % to wholesale market handling ^[5]. Ogun State's supply chain, characterised by warm humid conditions and long road-transport distances from growing regions in Jos and Kaduna, may present a different loss profile that has received limited empirical attention ^[6].

Mapping losses node-by-node is a prerequisite for designing cost-effective interventions, because a blanket investment in cold storage, for instance, does little if the main bottleneck is actually rough handling during loading ^[7]. This research therefore tracked tomato consignments through six supply chain stages in Abeokuta district across two cropping seasons, quantifying losses by volume and categorising them by cause mechanical, physiological, and pathological to identify where corrective effort would yield the greatest return.

Material and Methods

Research area description

Abeokuta district (7.15 °N, 3.35 °E) lies in the coastal lowlands of Ogun State, with a tropical climate averaging 28-33 °C and 75 % relative humidity during the survey period. Most tomatoes sold locally are sourced from Jos (Plateau State) and Kaduna, travelling 350-500 km by road. The district has one central wholesale market and roughly 150 retail vendors.

Corresponding Author:
Adewale Ogunlade
 Department of Agricultural
 and Food Engineering, Federal
 University of Agriculture,
 Abeokuta, Ogun State, Nigeria

Material

Thirty independent supply chains were selected by stratified random sampling 15 during the wet season season (July-October 2022) and 15 during dry season (November 2022-February 2023). Each chain was traced from the farm gate through sorting, transport, the wholesale market, the retail outlet, and where accessible to the consumer. Physical samples of 20 kg were tagged at the point of harvest and weighed at each subsequent node using calibrated digital scales (± 5 g). Damaged tomatoes at each stage were classified as mechanically injured (bruising, cuts), physiologically deteriorated (over-ripening, shrivelling), or pathologically infected (visible fungal or bacterial lesions) [8].

Methods

Loss percentage at each node was calculated as the weight reduction relative to the initial 20 kg tag lot. Cumulative loss was the running total from harvest to consumer. Ambient temperature and relative humidity were logged hourly during transport using portable data loggers (Elitech RC-4). Pearson correlation was used to test the association between mean transit temperature and transport-stage loss. Seasonal differences were compared with independent-samples t-tests ($p < 0.05$). All analyses used SPSS 26.0 [9].

Results

Across the 30 tracked consignments, average cumulative loss from farm gate to consumer was 26.4 %. The transport leg alone accounted for a quarter of total losses, followed by the wholesale market stage (Figure 1).

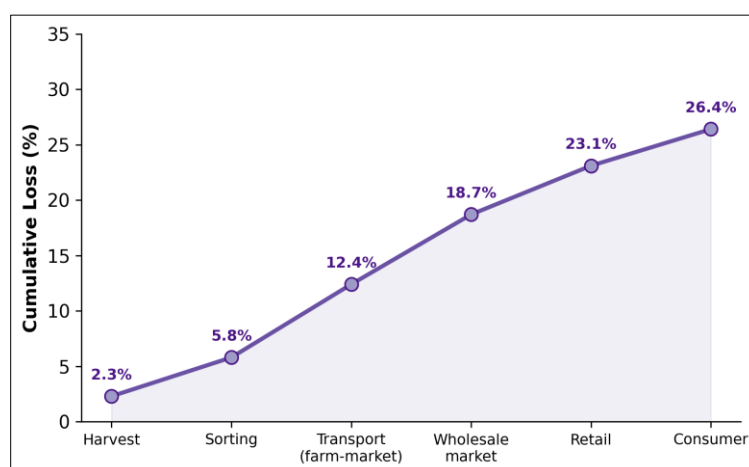


Fig 1: Cumulative post-harvest loss (%) in tomato supply chains across six stages (n = 30 chains)

Table 1: Mean stage-wise tomato loss (%) by season and overall

Stage	Wet season	Dry season	Overall	SD	p-value
Harvesting	2.8	1.7	2.3	0.9	0.034
Sorting	3.9	3.1	3.5	1.1	0.187
Transport	7.8	5.4	6.6	2.3	0.008
Wholesale	7.1	5.5	6.3	1.8	0.021
Retail	5.2	3.4	4.4	1.5	0.015
Consumer	3.8	2.7	3.3	1.2	0.063
Cumulative	30.6	21.8	26.4	4.1	0.001

Wet season losses were significantly higher than dry season losses at the transport and wholesale stages (Table 1), which

aligns with the higher ambient temperatures recorded during the monsoon months.

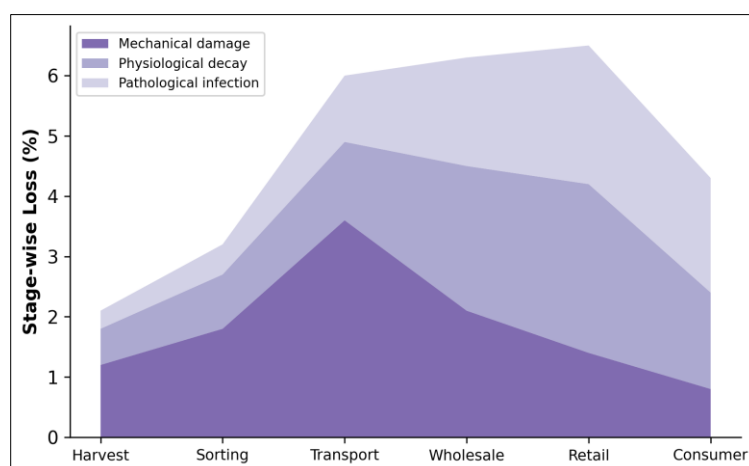
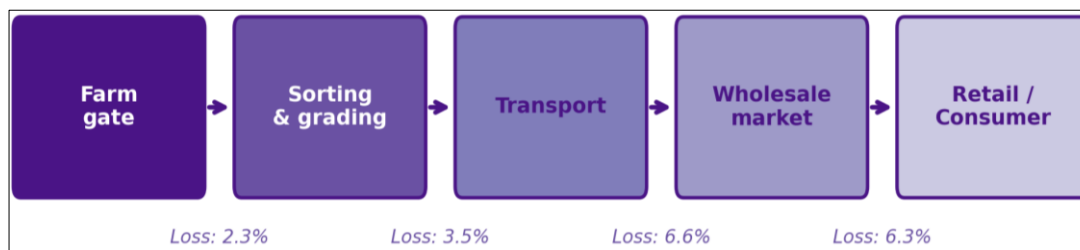
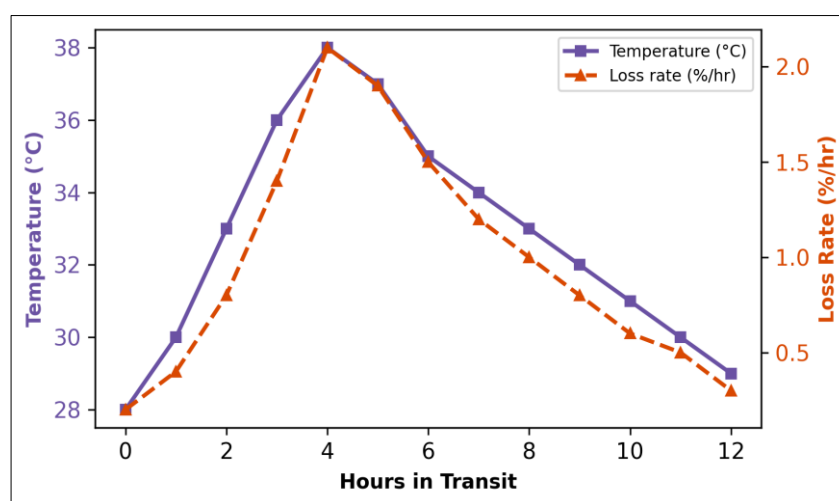


Fig 2: Stacked area chart of stage-wise loss (%) by cause category

Table 2: Timeline of loss progression in a representative wet season consignment

Time (h)	Stage	Temp (°C)	RH (%)	Stage loss	Cumul. loss
0	Harvest	28	88	2.8%	2.8%
2	Sorting	31	82	3.9%	6.7%
4-14	Transport	33-38	72-80	7.8%	14.5%
16-24	Wholesale	32	78	7.1%	21.6%
26-48	Retail	30	80	5.2%	26.8%
50-72	Consumer	29	84	3.8%	30.6%

**Fig 3:** Schematic of the tomato supply chain from farm gate to consumer with stage-wise loss percentages**Fig 4:** Ambient temperature and tomato loss rate during a 12-hour transport run in the wet season

Interpretation

The data paint a consistent picture: losses accelerate wherever tomatoes are exposed to high temperatures and rough handling for extended periods. Transport and wholesale handling together contributed nearly half of total losses. The strong positive correlation between transit temperature and loss rate ($r = 0.83$) suggests that even modest cooling pre-cooling before loading or use of ventilated trucks could trim transport losses by several percentage points.

Discussion

The cumulative loss of 26.4 % recorded here falls within the 20-30 % range commonly cited for Nigerian vegetable supply chains ^[10, 11], confirming that Abeokuta's tomato corridor is not an outlier. What the disaggregated data add is clarity on where the losses concentrate. Transport accounts for the largest single share, a finding that matches the observations of Nanda and colleagues in Kano State ^[12], though the absolute magnitude in Ogun State (6.6 %) is higher, likely because of longer haul distances and warmer average temperatures along the route.

Published interventions support the view that plastic crates reduce mechanical damage by 40-60 % compared with gunny sacks or wooden boxes ^[13]. And pre-cooling to 10-12

°C within two hours of harvest has been shown to extend shelf life by three to four days in tropical conditions ^[14]. The barrier, as noted by Kitinjo and AlHassan ^[15], is adoption cost: small-scale farmers rarely invest in returnable crates or pre-cooling infrastructure without subsidy or market-linked incentives.

The seasonal difference wet season losses being roughly 40 % higher than dry season underscores the role of ambient temperature as a driver. Because pathological infections accelerate in the warm, humid monsoon environment, extending the cold chain even partially into the wholesale market stage could yield disproportionate savings ^[16].

Conclusion

This research aimed to quantify tomato post-harvest losses at each stage of the supply chain in Abeokuta, Ogun State. The key findings show that cumulative losses averaged 26.4 %, with transport (6.6 %) and wholesale handling (6.3 %) being the two largest contributors. Mechanical damage predominated at farm and transport levels, while pathological infection was the leading cause at wholesale and retail stages.

For practitioners and policymakers, the practical message is that investment should be concentrated on two fronts: replacing traditional sacks with ventilated plastic crates to

cut mechanical injury, and introducing pre-cooling or shaded collection points to slow microbial spoilage during the critical first hours after harvest. Future work should evaluate the cost-benefit ratio of these interventions across a larger number of supply chains and explore whether direct farmer-to-retailer models bypassing the wholesale market entirely can reduce both loss and transaction costs.

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