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Review Article

Reducing Post-Harvest Losses in Tomato Value Chains in Nigeria: Handling, Cold Chain, Processing and Market Linkages

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Abstract

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Tomato is one of the most widely grown and consumed vegetables in Nigeria, yet a large share of each harvest never reaches the consumer in good condition. This review synthesises evidence on why tomatoes are lost after harvest, where in the value chain those losses concentrate, and which interventions most reliably reduce them. Losses are not caused by a single failure. They result from the biology of a soft, highly perishable fruit interacting with rough handling, heat, poor packaging, bad roads, delayed transport, absent cold storage, weak market coordination and limited processing capacity. In peak season, gluts depress prices and farmers may leave fruit unharvested or sell at a loss; in scarcity, consumers pay far more for less. The review shows that no single technology solves the problem. Gentle harvesting, shade, rigid ventilated crates, sorting and grading, pre-cooling, evaporative and solar cold storage, better transport scheduling, aggregation, and small-scale processing into paste, dried tomato and sauce together form a loss-reduction system. Low-cost practices pay first and fastest, while cold chain and processing require organisation, finance and reliable energy. The article closes with a practical, sequenced implementation pathway for farmer groups, cooperatives, aggregators and local governments.

Keywords: *tomato; post-harvest losses; cold chain; value chain; processing; Nigeria; food loss.*

1. Introduction

Tomato (Solanum lycopersicum) is central to Nigerian diets, cooking and trade. It is grown in every agro-ecological zone, with large production clusters in the north and year-round demand in southern cities. For millions of smallholders, tomato is both food and cash: a short-cycle crop that can be harvested several times, sold quickly, and used to pay school fees, buy inputs and smooth household income between staple harvests.

Yet tomato farmers face a cruel paradox. A good harvest can mean a bad income. When many farmers harvest at the same time, markets flood, prices collapse, and fruit that cannot be stored or processed quickly rots in baskets, on trucks and at stalls. When supply is scarce, prices spike, but the farmers who lost their crop to poor handling have little left to sell. Post-harvest loss is therefore not only a technical problem of spoilage. It is an income problem, a nutrition problem and a food-system problem.

This article asks three questions. First, where and why are tomatoes lost after harvest in Nigeria? Second, which handling, storage, transport and processing interventions actually reduce losses under smallholder conditions? Third, how should those interventions be sequenced and organised so that they pay for themselves and reach the farmers and traders who need them most? The article is a narrative review of peer-reviewed studies, institutional reports and field practice, organised around the value chain rather than around a single technology.

2. Why Tomato Is So Vulnerable After Harvest

Tomato is a living, respiring fruit with high water content, thin skin and soft flesh. After harvest it continues to respire, ripen, soften and lose water. Heat accelerates every damaging process: respiration, ripening, water loss, microbial growth and senescence. A delay of a few hours in the sun can matter more than a delay of days in a cool store. Bruising is equally important. A bruise that is invisible at harvest becomes a soft spot, then a rot, then a reason for a buyer to reject a whole basket.

Four biological and physical mechanisms dominate losses. Mechanical damage from rough picking,

overfilling, stacking and vibration creates entry points for fungi and bacteria. Water loss through the skin and stem scar shrinks fruit, wrinkles the surface and reduces saleable weight. Over-ripening turns firm, transportable fruit into soft fruit that cannot survive another journey. And microbial decay, especially when warm, wet and damaged fruit are packed together, spreads from one fruit to its neighbours. Any intervention that does not address heat, damage, time and hygiene will have limited effect, however sophisticated it looks.

Variety and maturity at harvest also matter. Varieties bred for fresh-market firmness and shelf life tolerate handling better than soft, thin-skinned types. Harvesting at the mature-green to breaker stage for distant markets, and at full ripeness only for nearby sale or immediate processing, is one of the cheapest loss-reduction decisions a farmer can make. Harvesting in the cool of the early morning, rather than at midday, reduces field heat and slows deterioration from the first hour.

3. Where Losses Happen: Mapping the Value Chain

Losses are distributed along the whole chain, not concentrated in one place. That is why single-point solutions disappoint: fixing storage without fixing transport, or fixing transport without fixing packaging, simply moves the loss downstream. Figure 1 summarises the pattern described in Nigerian and West African field studies: harvest and field handling, on-farm sorting and packing, transport, wholesale and retail display, and delays before consumption or processing each contribute a meaningful share.

At harvest, losses come from picking over-ripe or damaged fruit, dropping fruit, using sharp containers, and leaving harvested fruit in the sun. On-farm sorting is often done on bare ground, where fruit is contaminated and bruised, and where good and damaged fruit are mixed. Packing into oversized woven baskets or sacks, often overfilled and stacked under heavy loads, crushes the fruit at the bottom. During transport, bad roads, overloading, long waits and open trucks exposed to sun and dust compound the damage. At wholesale and retail, repeated handling, poor display, lack of shade and slow turnover mean fruit that survived transport is lost at the stall. Finally, when processing is unavailable or delayed, surplus that could have been preserved is simply discarded.

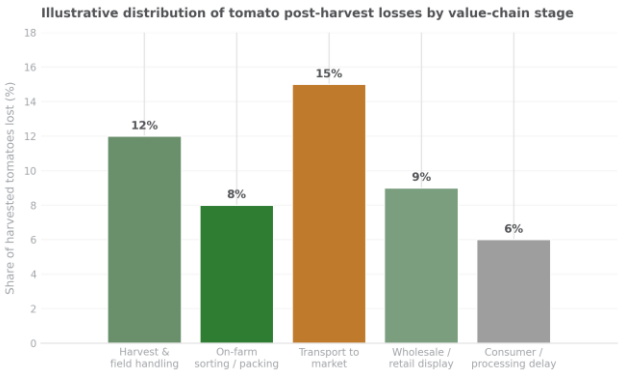


Figure 1. Illustrative distribution of tomato post-harvest losses by value-chain stage. Values are illustrative and summarise the direction of evidence in field studies cited in the text; they are not a pooled meta-analytic estimate. Total losses in poorly served chains commonly reach 40–50% of harvested volume.

The geography of loss also matters. Long-distance chains from northern production zones to southern consumption centres face the highest transport and time risks. Short, local chains lose less in transport but can lose heavily at harvest and market if shade, crates and quick sale are absent. Urban markets with high turnover can absorb more volume, but also expose fruit to repeated handling and heat. Any loss-reduction plan must therefore start by walking the specific chain: where does fruit sit, for how long, in what container, at what temperature, and who handles it next?

4. Harvest, Handling and Packaging: The Cheapest Wins

The lowest-cost interventions are also among the most effective, because they act at the moment when damage is created and is still preventable. Gentle harvesting by hand, picking into shallow, smooth containers, and avoiding dropping or throwing fruit reduce bruising immediately. Harvesting early in the morning, keeping harvested fruit in shade, and moving it quickly to a shaded sorting area reduce field heat without any equipment.

Sorting and grading deserve more attention than they usually receive. Removing damaged, diseased and over-ripe fruit before packing prevents decay from spreading. Grading by size, colour and firmness lets farmers and traders match fruit to its best use: firm fruit for distant markets, ripe fruit for nearby sale, and soft or damaged but safe fruit for immediate processing. Grading also creates price transparency. When buyers can see uniform quality, they pay more reliably and reject less arbitrarily.

Packaging is the single most visible change in many successful programmes. Rigid, ventilated plastic crates protect fruit far better than woven baskets or sacks. They stack without crushing, allow air circulation, are easy to clean, and can be reused many times. Their cost is the main barrier, which is why crate-rental, cooperative ownership and deposit-return systems matter more than simply telling farmers to buy crates. Lining crates, avoiding overfilling, and not sitting or standing on packed crates are small disciplines with large returns. Table 1 summarises the main causes of loss and the practical responses at each stage.

Table 1. Main causes of tomato post-harvest loss and practical responses by value-chain stage.

Stage	Main cause of loss	Practical response	Cost / effort
Harvest	Rough picking, midday heat, bruising	Pick early morning; shallow containers; gentle handling	Low
Sorting / packing	Mixed good and damaged fruit; overfilled baskets	Sort on clean surface; grade; use rigid ventilated crates	Low–medium
Transport	Vibration, crushing, sun, delays, bad roads	Do not overload; shade loads; schedule; maintain roads	Medium
Wholesale / retail	Repeated handling; heat; slow turnover	Shade stalls; display in crates; first-in-first-out	Low

Consumption / processing delay	Glut; no buyer; no processor	Aggregate; link to processors; preserve surplus quickly	Medium–high

5. Cold Chain: What Works When Electricity Does Not

Cold is the most powerful tool for slowing ripening and decay, but it is also the hardest to deliver where electricity is unreliable or absent. The goal is not necessarily a modern refrigerated warehouse. It is to remove field heat quickly, keep fruit cool and shaded, and shorten the time between harvest and sale or processing. Even a few degrees of cooling, consistently applied, can add days of shelf life.

Pre-cooling and shade are the first steps. A shaded, ventilated aggregation shed, with fruit kept off the ground and out of direct sun, is far better than a pile of baskets in an open yard. Evaporative coolers, including zero-energy cool chambers made from brick, sand and water, can reduce temperature and raise humidity using no electricity. They are best suited to short-term holding, for fruit that will be sold within days, and they require water, maintenance and training to work well.

Solar-powered cold rooms and cold hubs are the most promising medium-scale option. Shared, pay-per-use cold rooms at aggregation points let many smallholders store fruit for a fee, wait for better prices, and meet buyers who need reliable volume. Their success depends on location, utilisation, transparent pricing, maintenance and a business model that does not depend on a single donor or season. Where utilisation is low, costs per crate rise and the facility falls idle. Where it is well managed, cold storage changes bargaining power: farmers are no longer forced to sell today at any price.

Transport cooling is often overlooked. Refrigerated trucks are rare and expensive for smallholders, but shaded, ventilated trucks, night transport, and avoiding long waits at loading points all reduce heat exposure. Consolidating loads, so that a truck leaves full and on time rather than half-empty and late, is a logistics improvement that costs little and saves much. Figure 2 shows how losses fall when practices are combined, rather than adopted in isolation.

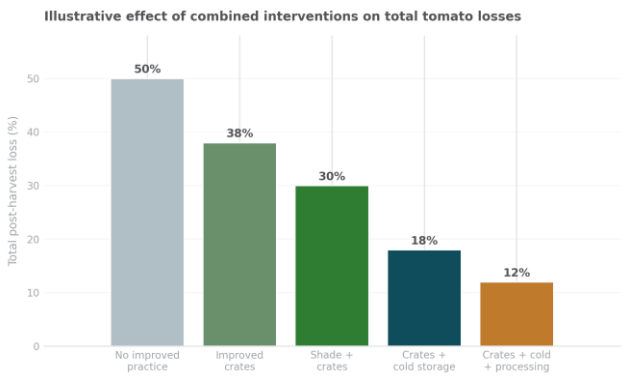


Figure 2. Illustrative effect of combined interventions on total tomato losses. Crates alone help; shade, cold storage and processing together reduce losses far more. Values are illustrative and summarise the pattern reported in field and pilot studies; they are not pooled effect sizes.

6. Processing: Turning Surplus into Shelf-Stable Value

Processing is the safety valve for gluts. When fresh markets cannot absorb a harvest, processing converts perishable fruit into paste, puree, dried tomato, sauce and powder that can be stored, transported and sold later. It does not need to be industrial to matter. Small-scale, community-level processing — solar drying, small paste lines, and batch sauce production — can absorb the ripe and slightly damaged fruit that fresh buyers reject, provided food safety and quality are maintained.

Each product has different requirements. Solar drying is low-cost and low-energy, but needs hygienic drying surfaces, protection from dust and insects, and consistent slice thickness. Tomato paste requires heat, clean water, packaging and quality control, and it competes with imported paste on price. Sauce and stew bases can use local recipes and packaging, but need reliable labelling, shelf-life testing and market access. Dried tomato and powder can serve niche and institutional buyers, but only if quality is consistent from batch to batch.

Processing only works if it is linked to supply and demand. A processing unit without a steady supply of affordable fruit, or without buyers for its output, will fail even if the technology is sound. Contracts with farmer groups, scheduled delivery, transparent pricing for processing-grade fruit, and links to schools, hospitals, caterers and retailers create the demand that justifies investment. Processing should therefore be planned as a business, not as a demonstration. Table 2 compares the main technologies by cost, shelf-life gain and suitability.

Table 2. Post-harvest technologies: cost, benefit and suitability for smallholder tomato chains.

Technology	What it does	Relative cost	Best for
Rigid ventilated crates	Prevents crushing; reusable	Low–medium	All chains; first investment
Shade + sorting shed	Removes heat; improves grading	Low	Farm and aggregation points
Evaporative cooler	Cools and humidifies without power	Low–medium	Short-term holding
Solar cold room (shared)	Stores fruit for days; improves bargaining	High (shared)	Aggregation hubs
Solar drying	Preserves surplus as dried tomato	Low	Glut periods; rural markets
Small-scale paste / sauce	Converts surplus to shelf-stable product	Medium–high	Near towns; organised groups

7. Markets, Aggregation and Coordination

Many losses are coordination failures, not technical failures. Farmers harvest without knowing whether a buyer will come. Traders arrive without knowing how much fruit will be ready. Transporters wait for loads that never fill. Markets open and close without reliable information on prices or volumes. Reducing loss therefore requires better coordination as much as better equipment.

Aggregation is the key organisational step. When farmers bulk their produce at a collection point, they can grade

together, negotiate together, fill a truck together, and meet larger buyers who would not deal with individual smallholders. Cooperatives and farmer groups can own crates, manage a cold room, employ a grader, and keep records that build trust with buyers. Aggregation also makes extension, finance and quality training cheaper to deliver, because services reach many farmers at one point.

Market information and contracting help in different ways. Mobile price alerts, even simple SMS or voice messages, let farmers decide when to harvest, where to sell, and whether to store or process. Forward contracts and out-grower arrangements, when fair and honoured, reduce the risk that fruit will be harvested with no buyer. Digital platforms can help, but they are not a substitute for trust, transparent weighing, prompt payment and dispute resolution. A platform that lists prices no one honours will be abandoned quickly.

Women and youth are central to tomato trade and processing in Nigeria. Women dominate retail, sorting, drying and small-scale processing, yet often have less access to credit, cold storage, transport and market stalls. Interventions that ignore who actually handles, sorts and sells tomatoes will miss the people whose decisions determine losses. Gender-responsive design — safe market spaces, childcare-aware meeting times, credit that does not require land as collateral, and leadership roles for women traders and processors — is not an add-on. It is part of making the chain work.

8. Economics: Does Reducing Loss Pay?

Farmers and traders will adopt loss-reduction practices only if they pay. The economics are often favourable, but they are not automatic. Crates pay when they are reused many times and when better quality earns a price premium or reduces rejection. Shade and sorting pay almost immediately because they cost little and reduce visible waste. Cold storage pays when utilisation is high, when it allows farmers to wait for better prices, and when the fee is lower than the value of the loss avoided. Processing pays when there is a reliable market for the processed product and when processing-grade fruit is priced fairly.

Three costs are commonly underestimated. The first is labour: sorting, grading, careful packing and record-keeping take time, and that time must be valued. The second is maintenance: crates break, coolers need water and cleaning, solar panels need servicing, and processing equipment needs spare parts. The third is working capital: holding fruit, even for a few days, means delaying payment, and farmers who need cash today may not be able to wait. Finance that matches the cash-flow pattern of the chain — short, flexible, and tied to aggregation — matters more than large, one-off grants.

Table 3 gives a simple decision framework. It is not a precise costing, because prices, distances and utilisation vary widely. It is a way for a farmer group or cooperative to ask the right questions before investing: what will it cost, how often will it be used, what loss will it prevent, and who will pay for maintenance? Pilot testing on a small scale, with careful records of losses before and after, is the most reliable way to answer those questions locally.

Table 3. Simple economics: when does each investment pay? A decision guide for farmer groups.

Investment	Pays when…	Watch out for…	First step
Crates (owned / rented)	Reused often; quality premium exists	Theft, breakage, hoarding	Start with rental / deposit
Shade / sorting shed	Used daily in season; near farm	Idle in off-season	Build at aggregation point
Evaporative cooler	Water available; short holding	Needs daily maintenance	Pilot one unit; record losses
Solar cold room	High utilisation; good location	Low use; high fees; power faults	Survey demand; set clear fees
Small processing unit	Buyer confirmed; supply scheduled	No buyer; inconsistent quality	Secure buyer before building

9. A Sequenced Implementation Pathway

The most common mistake is to start with the most expensive technology. The pathway below starts with practices that cost little, build trust and generate quick wins, and only then moves to shared infrastructure and processing. Each step creates the organisation and cash flow needed for the next.

Step 1 — Harvest and handling discipline (weeks 0–4): train on maturity, morning harvest, shade, gentle handling, sorting and grading. Introduce crates on a rental or cooperative basis. Measure losses before and after, using simple crate counts and rejection records.

Step 2 — Aggregation and market linkage (months 1–3): establish a collection point, agree on grading standards, weighing and payment rules, and link to at least two buyers. Start price-information sharing and scheduled transport. Record volumes, prices and losses weekly.

Step 3 — Shared cooling (months 3–12): if utilisation justifies it, pilot an evaporative cooler or solar cold room at the aggregation point, with transparent fees, a caretaker and a maintenance fund. Use cold storage to wait for better prices and to meet buyers who need consistent supply, not to hoard fruit that should have been processed.

Step 4 — Processing for surplus (months 6–18): once supply and demand are reliable, add small-scale drying or paste/sauce processing for surplus and processing-grade fruit. Secure buyers first, test product quality, and keep food-safety records. Reinvest processing margins into crates, cooling and transport.

Table 4 summarises this pathway for planners and extension services. It is a heuristic, not a blueprint. Local conditions — distance to market, road quality, water availability, energy, buyer requirements and group capacity — should adapt the sequence.

Table 4. Sequenced pathway for reducing tomato post-harvest losses.

Phase	Priority actions	Who leads	Success measure

1. Quick wins	Gentle harvest; shade; sorting; crates	Farmers + extension	Lower bruising; fewer rejections
2. Aggregation	Collection point; grading; buyer links	Cooperative / group	Higher volumes; better prices
3. Cooling	Shared cooler / cold room; fees	Cooperative + local govt	Longer shelf life; less distress sale
4. Processing	Drying / paste for surplus	Group + private buyer	Surplus absorbed; new income
Cross-cutting	Finance; training; records; women's leadership	All partners	Sustained use; maintained assets

10. Policy Implications

Policy should shift from subsidising single pieces of equipment to building the system that makes equipment useful. Three priorities stand out. First, invest in rural infrastructure that reduces loss for everyone: all-season feeder roads, market shade and water, reliable weighing, and aggregation sheds. A good road and a shaded market can reduce losses as much as a new technology, and they benefit every crop, not only tomato.

Second, support shared, well-governed cold chain and processing rather than giving equipment to individuals who cannot maintain it. Public funds can de-risk shared facilities, support business planning and maintenance, and ensure transparent access for women and smallholders. Private operators should be encouraged where they can run facilities profitably, with clear service standards and fee transparency.

Third, strengthen market systems: reliable price information, contract enforcement, food-safety standards that are achievable for small processors, and finance that matches the timing of harvest and storage. Extension should teach loss measurement, not only production: farmers who count losses, in crates and in naira, make better decisions about crates, cooling and processing than farmers who are simply told to adopt a technology.

11. Limitations and Future Research

This review has limitations. Loss estimates vary widely by season, location, variety and measurement method, so the illustrative figures should not be treated as national averages. Many intervention studies are short-term pilots with intensive support, and their results may not persist when support ends. Evidence on the long-term profitability of shared cold rooms, on gendered labour effects of sorting and processing, and on food-safety outcomes of small-scale processing remains thinner than evidence on technical efficacy. Future research should use standardised loss measurement, track costs and revenues over multiple seasons, and evaluate organisational models — not only technologies — in real market conditions.

12. Conclusion

Tomato post-harvest losses in Nigeria are large, costly and largely preventable. They are not caused by farmers being careless, but by a perishable fruit meeting heat, rough handling, poor packaging, long transport, absent cooling and uncoordinated markets. The solution is not a single technology. It is a sequenced system: gentle handling, shade, sorting and crates first; aggregation and market linkage next; shared cooling when utilisation justifies it; and processing to absorb surplus and create shelf-stable value. When those pieces are built together, with finance, training and leadership that include the women and traders who actually handle tomatoes, losses fall, incomes rise, and more of each harvest reaches the people who need it.

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Conflict of Interest

The authors declare no conflict of interest.

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