Smoothing tomatoes' bumpy ride to market

Potholes and other road hazards are not only the bane of motorists' lives; tomatoes, too, suffer when they are transported across rough surfaces over long distances.

TOMATOES ARE ONE of consumers' favourite foods. According to the Food and Agriculture Organization of the United Nations (FAO), it is the second most widely cultivated fruit in the world. Tomatoes are also good for us because of their high levels of antioxidant compounds.

Although South African tomatoes are largely grown for domestic consumption, their road to market is not a smooth one. The way they are handled once they've been harvested is the greatest hazard to the quality and shelf life of tomatoes.

Post-harvest losses are caused by mechanical injuries, inadequate storage, unsuitable handling and transport, and the length of time they are left on display in retail outlets.

The physical damage they suffer as a result may cause metabolic and physiological changes that negatively impact on flavour, smell and firmness. Physical damage may also significantly affect the chemical and physical composition of the pericarp and locular tissue of tomatoes.

The incidence and severity of damage suffered depends on the impact energy, number of impacts, cultivar and ripening stage, all of which adds up during a tomato's post-harvest life.

It stands to reason, therefore, that better management of transport logistics as well as handling practices between field and consumer, should result in better quality tomatoes with a longer shelf life.

Technologies that have been developed to curb post-harvest losses include use of 1-MCP to delay ripening, hot water rinsing and brushing to slow down decay, a short anoxia/hypoxia treatment to reduce decay at relatively high storage temperatures, and coating to reduce physiological deterioration.

Of all the potentially damaging activities, transport seems to be particularly troublesome in South Africa. The rural road network – on which most farmers depend – is in a poor state of repair, and tomatoes are reaching the market the worse for it. Not only do they suffer physical damage, but the time it takes to reach either the packhouse from the field, or the market from the packhouse, often leaves the tomatoes for too long at storage temperatures that are not optimal.

Previous studies have noted that, depending on the harvest sites, tomatoes can travel up to 128km before removal of field heat starts; in certain instances the situation is aggravated when the tomatoes are not transported to the packhouse as soon as they have been picked. From the packhouse, the tomatoes are commonly transported in non-refrigerated vehicles to fresh produce markets, representing a break in the cold chain.

Despite the fact that the post-harvest stresses that tomatoes are subjected to are well documented, there is no model that relates the damage incurred during transit to the shelf life of tomatoes. Having identified this gap, Prof. Tilahun Workneh, of the Department of Agricultural Engineering at the University of KwaZulu-Natal, secured PHI Programme and industry funding for a study that would evaluate the quality losses in a South African tomato supply chain due to transportation and handling practices.

1 Prof. Workneh (right) and his students, (from left) Getachew Neme, Sabelo Shezi and Kipchumba Cherono examine tomatoes that were treated with anolyte water on day zero of storage and then stored for 30 days under two different conditions.

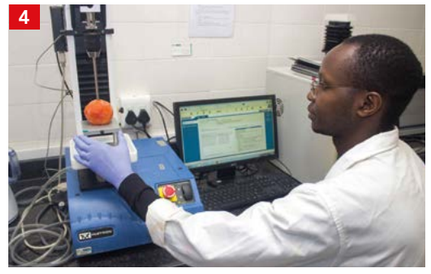
Project scope and objectives

The project scope covered post-harvest handling and road transport activities from the field to the fresh produce market.

The scope was broken down into seven objectives:

Measure and quantify the stresses and strains exerted on tomatoes during a range of transport conditions (speeds, packaging types, vehicle types, etc.).

1. Measure and quantify the route conditions followed in a typical tomato post-harvest logistics chain.
2. Empirically investigate the quality and shelf life of tomatoes delivered to the Pietermaritzburg fresh produce market via the various supply chain routes originating at the different ZZ2 packhouses in Limpopo.
3. Sample and test tomato quality attributes *in situ* at different points in the supply chain and from different positions in the bins in which they are transported. ZZ2 and an emerging farmer identified the sites for this part of the study.



4. Develop deterioration models that can be used to predict quality losses under different supply chain conditions.
5. Refine an existing model for the management of the transport logistics chain of post-harvest tomatoes to be relevant to South African conditions.
6. Develop integrated post-harvest treatments and handling methods to extend the shelf life of tomatoes.

Methodology

Tomatoes for analysis were sourced from ZZ2 farms in three regions of the Limpopo province. ZZ2 is South Africa's single largest producer of tomatoes. Mohale Farming within the Letaba Municipality in Limpopo was the emerging farmer whose participation ensured that the data generated from the study would represent the full spectrum of tomato producers.

Two experimental trials, one during

PROJECT TITLE
Evaluation of quality losses in a South African tomato supply chain due to transportation and handling effects

PRINCIPAL INVESTIGATOR
Prof. T S Workneh

CONTACT DETAILS
+27 (0)33 260 5818
Seyoum@ukzn.ac.za

DURATION
Two years

PHI PROGRAMME & INDUSTRY CONTRIBUTIONS
R752 168 & R332 168

LEAD INSTITUTIONS
University of Kwa-Zulu Natal (Department of Agricultural Engineering) in collaboration with the University of Pretoria (Department of Civil Engineering)

BENEFICIARY
The South African tomato industry

FOCUS AREA
Logistics and post-harvest physiology

HUMAN CAPITAL DEVELOPMENT
One PhD student, two MSc students and one Hons student

PUBLICATIONS
Seven

PRESENTATIONS
Seven

Prof. Tilahun Workneh assesses the firmness of a ripe red tomato using a universal testing machine (**2**), and discusses surface defects on tomato skins with Sabelo Shezi (**3**). **4** Kipchumba Cherono analyses the texture of a ripe red tomato.

1 Prof. Wynand Steyn, from the University of Pretoria, conducted road profiling and testing to measure surface roughness, texture and rutting at road and highway speeds.
2 Lugs filled with tomatoes are stacked on a trailer on their way to the packhouse.
3 Accelerometers and pressure mats were used to measure the frequencies that tomatoes were exposed to while in transit.
4 Tomatoes' maturity stages at harvesting determine their end market. Green-mature fruit are usually sent to a distant market, while pink fruit are destined to go to the local market. When red and starting to soften, fruit is ready for consumption or used for canning and processing. Mixing different maturities in one carton may lead to a higher incidence of damaged fruit.

winter (June–July) and the other in summer (September–October), were carried out to cover the full growing season.

Accelerometers and pressure mats were used to measure the frequencies that tomatoes were exposed to while in transit. Road conditions were evaluated separately, along with the effect of road conditions on the vehicles used.

Harvested tomatoes at three maturity stages were transported over three supply roads, each in a different condition, to the Pietermaritzburg fresh produce market depot. From there they were transported to the laboratory and assigned different treatments under a completely randomised design. The treated tomatoes were stored under either ambient or controlled temperature (11°C) conditions for 30 days. During this time, the tomatoes' firmness, colour, pH, titratable acidity, marketability, total soluble solids, total bacterial counts, electron microscopy imaging, sugar and bioactive compounds were measured and analysed

Additionally, seven post-harvest treatments, individually and in different combinations, were used on all the samples. These included biocontrol B13 coating, gum arabic coating, hot water treatment, chlorine and electrochemically active water (anolyte). Sampling was done at selected intervals, and data collected will be analysed and used to develop shelf life and quality models.

Biochemical and chemical analyses of the samples were carried out using high-performance liquid chromatography (HPLC) and spectrophotometric methods. In this case, the parameters analysed included sugar content, ascorbic acid content and lycopene.

The infield experiment involved two handling conditions (bins and lugs), two periods to precooling (six and two hours), two storage conditions (controlled temperature and ambient) and two harvesting times (morning and afternoon), replicated on two farms that supplied tomatoes to two packhouses in Limpopo.

Results

In-transit pressures do affect the shelf life of tomatoes. The induced damage is a function of the road condition, the period of time tomatoes are exposed to certain frequencies and the packaging method. Given that tomatoes transported in bins ripened faster and had more structural damage than those transported in cartons, it is clear that packaging choices during transport offer an important avenue to mitigate post-harvest losses.

Post-harvest disinfection and coating treatments have a significant impact on the quality of tomatoes stored under both ambient and refrigerated temperatures. Treatments that combined surface decontamination and bio-coating resulted in the best shelf life and quality for pink and red tomatoes. Hot water treatment delivered the best results for tomatoes harvested at the green-mature stage.

The summer season tomato samples ripened and deteriorated faster than those grown in winter, which is expected from a biochemical and microbiological perspective. The maximum shelf life for tomato samples supplied during winter was 32 days, compared to 24 days for the summer samples.

WHY THE PROJECT MATTERS

- Quantifying the impact that road surface quality has on the shelf life of tomatoes can help to determine transportation routes and incentivise/support the development of infrastructure.
- An improved understanding of transport conditions and their impact on post-harvest damage can increase the productivity of the tomato industry.
- An integrated approach to the post-harvest management of tomatoes can be achieved by combining treatment and handling best practices.
- The study delivered information that both large-scale and emerging farmers can use to improve their post-harvest operations.
- The quality deterioration model can be used as a tool to support decision-making in the tomato supply chain, and may be adapted to other supply chains.

> "When transported across rough surfaces over long distances, tomatoes may suffer physical damage resulting in metabolic and physiological changes that negatively impact on flavour, smell and firmness of the fruit.
>
> **Prof. Tilahun Workneh**

5–7 Tomatoes transported in bins ripen faster and have more structural damage than those transported in cartons.
8 The rural road network – on which most farmers depend – is in a poor state of repair, and tomatoes are reaching the market the worse for it.
9 Tomatoes arriving at the Cape Town fresh produce market.