

Optimising post-harvest packaging of table grapes



Packaging solutions to help combat decay during post-harvest storage

Choosing the most optimised packaging combinations is vital for growers aiming to export premium-quality table grapes.

The presence of plant pathogens such as *Botrytis cinerea*, *Penicillium expansum*, *Alternaria alternata*, *Cladosporium spp.*, and *Aspergillus spp.* can impact the quality of table grapes destined for export.

A jointly-funded research project by the South African Table Grape Industry (SATI) and the Post-Harvest Innovation (PHI) Programme was spearheaded by Dr Johan Fourie, Dr Alana den Breeyen and Daniël Viljoen of ExperiCo. They sought to ascertain how to optimise post-harvest packaging to prolong storage and maintain table grape quality.



Dr Alana den Breeyen of ExperiCo.

Sulphur dioxide use in packaging is well established for limiting decay during shipment and storage. However, its efficacy is influenced by several factors, including pre-harvest quality, infection levels and post-harvest conditions. These factors were investigated in this study, initiated in 2022, which involved a series of controlled trials evaluating their combined effects on decay control and post-harvest performance.

A storied history

Sulphur dioxide (SO₂), long recognised for its role in combating decay in the table grape industry, has been in use for just over a century, with its earliest documentation traced to the United States. Dr Fourie referenced the work of Lazar Ginsburg, a leading South African researcher at the Fruit and Food Technology Research Institute during the 1970s and 1980s, noting the close collaboration between South African scientists and the prominent US researcher, Dr K.E. Nelson. “What is particularly interesting,” he said, “is that whilst US researchers were slightly ahead in developing the second-stage SO₂ sheet, the work was closely linked with South African research.”

Yet Dr Fourie stressed that innovation remains as critical today as it was then. Shifting market expectations and increasingly complex logistics and supply-chain ecosystems now demand far more than good commodity quality alone. As packaging has evolved into a strategic contributor across both the supply and value chains, Dr Fourie and his team embarked on a programme to identify and define current best practices suited to these new realities.

The changing landscape of SO₂ sheets

Manufacturers had introduced new types of SO₂ sheets. One of the main objectives of the research was to test the SO₂ release patterns and efficacy of different SO₂ sheet types for confining decay.

For Dr Fourie, SO₂ remains a key and well-validated intervention for managing post-harvest decay caused by *Botrytis cinerea* in table grapes.

Role of SO₂ and packaging combinations

Dr Den Breeyen explained that a decision had to be made about every component of packaging –

from the SO₂ sheet, liner bag, moisture absorbent material and punnet type to ventilation, perforation, packer's knowledge and cooling.

Considering this, SO₂ is a vital antimicrobial and antifungal agent, particularly in the post-harvest storage of table grapes. However, research has shown that thin-skinned table-grape cultivars may develop SO₂ burn when overexposed. This project evaluated SO₂ sheets against the *Botrytis cinerea*, *Alternaria alternata*, and *Penicillium spp.* Four table-grape cultivars, namely 'Sweet Celebration™', 'Sweet Globe™', 'AUTUMNCRISP®', and 'Crimson Seedless', were included.



AUTUMNCRISP® & Crimson Seedless in heat-sealed punnets.

Specific amounts of SO₂ must be released, in the right combination, prior to and during cold storage, says Dr Fourie. "If the SO₂ in the sheet is too low, the incidence of decay increases; if too high, the table-grape berries incur SO₂ damage."

The mechanics of a SO₂ sheet

SO₂ sheets used for preserving table grapes during storage have a dual-release mechanism. The sheets absorb moisture from the table grapes and environment, creating a chemical reaction. The first release is a quick burst that aims to kill pathogens whilst stabilising the table grape itself. The second is a more moderate, modulated release with the goal of constraining the growth of already present infections and controlling the spread between berries.

Regarding the chemistry involved, specifically sodium metabisulphite (Na₂S₂O₅), Dr Fourie observed that high humidity was enough to kick-start the process.

Though SO₂ sheets need moisture to activate, it is not "free water". The latter had to be avoided, as it could have a damaging effect on berries, releasing SO₂ too quickly. Berry cracking, decay development and initiation of infections could follow. He confirmed that the right term for this type of moisture was relative humidity (RH), which is the water vapour in the air. "The higher the relative humidity in the environment, the quicker SO₂ will be released from the first stage. If very low, the slower and lower SO₂ will be released."

He further explained that the SO₂ sheet can be made of either paper or plastic. The sheet comprises a wax- or resin-based matrix incorporating Na₂S₂O₅ particles as the active component. In addition, one of the matrix surfaces is uni-directional, i.e. coated with the active ingredient, which is also the origin of that first, quick release of SO₂. Everything revolves around the matrix in which the Na₂S₂O₅ is embedded. Ultimately, that determines the duration and preservation level.

Getting it right

Dr Fourie reiterated the importance of knowing what the sheet does, and over what duration SO₂ is released. He explained that the components incorporated into the matrix constitute proprietary information. In the past, manufacturers would typically specify the mass of the active ingredient (e.g. 6 or 7 g). However, the performance is more dependent on the matrix formulation as a whole, rather than solely on the grammage. "In the old days when it was paper only, and not today's plastic, the grammage of SO₂ was quite important – then we distinguished between 6, 7, or 9 g, to know how long SO₂ would last and the preservation level."

He said it is vital that growers learn more about SO₂ sheets and know for how long they plan to store the table grapes so that when they are packed, growers can make provision for long-term storage – for example, by using a slightly less perforated bag, and SO₂ sheet of a higher release rate in the second stage. However, storage and packaging are often not clear from the outset; plans could change depending on a number of variables or decisions made by stakeholders.

Liner bags

When considering liner bags as part of packaging, another important objective of the research was to determine the role of different inner packaging combinations in post-storage quality. Dr Fourie took great care to explain the role of the liner perforations, specifically the perforation area. He defined it as being determined by the number and size of the holes and the dimensions of the bag. For example, in reference to a liner described as 120 by 5, it simply means 120 holes of 5 millimetres each – which relates to the calculated perforated area of a liner.

He said that if the perforated area is too large, “SO₂ can be lost to an extent where it is no longer present at an effective dose, and hence decay control is impaired.” The bigger the holes, the lower the RH, the lower the SO₂ flowing out of the larger perforations of the bag. Conversely, if the “perforated area is too low, free water may accumulate, which relates to berry cracking and SO₂ damage”.

The confinement of moisture or retention depends on the perforation area of the liner bag. A sufficient concentration of SO₂ is necessary to maintain microbial control over time. Bags with fewer perforations retain more moisture, leading to higher SO₂ concentrations and a longer presence.

The growing need for science-backed decision-making and an evolving market require that growers know the product in use and that they regularly consult researchers and manufacturers.

Moisture-absorbing material

Dr Fourie pointed out the limitations of moisture absorbing materials (MAMs) and their dependence on type. These are also passive rather than active absorbers. It is important that growers know what they want to achieve. “If growers want to reduce SO₂, the MAM has to be placed below the SO₂ sheet (directly on the grapes). If they want to reduce and trap moisture, it has to be placed above the SO₂ sheet.”

Punnet type matters

The punnet type is equally important as part of packaging. In the absence of sufficient ventilation holes, punnets may act as a barrier between the SO₂ sheet and the grapes. An unvented top of a

punnet may also act as a barrier, trapping warmish air from respiration, and leading to condensation and accumulation of free water. Understandably, there is a major difference between possible water accumulation and SO₂ levels when using clamshell punnets and open-top, heat-sealed punnets.

Dr Den Breeyen emphasised that clamshell punnets tend to trap moisture more than the open-top ones do. Like a human being swathed in plastic, the punnet may trap moisture in the table grapes amid all the layers of plastic packaging, especially when not sufficiently ventilated.

Humidity and temperature

Another objective was to identify optimal packaging combinations for decay control under different pre-packaging and post-harvest extremes, specifically assessing the impact of moisture and temperature abuse conditions on SO₂ treatment efficacy.

Dr Fourie is adamant that condensation is not the single most dangerous amplifier of SO₂ damage. Equally important considerations are the liner bag used – specifically the perforated area, punnet type, and the whole temperature chain management, avoiding detrimental temperature spikes.

The difference between transpiration and respiration became relevant, as they are the two main physiological processes of concern in the decline of post-harvest quality. Transpiration occurs when water vapour is released from the fruit surface, leading to wilting and stem desiccation. Respiration, on the other hand, is the post-harvest metabolic process where living berry tissues absorb oxygen and break down stored organic compounds – sugars and acids – to produce carbon dioxide, water and heat.

During their table-grape trials, Dr Fourie and his team also had to consider moisture levels and losses as part of quality management, besides the release and availability of SO₂. In non-perforated bags or less ventilated liners, the RH will be almost 100%. This reduces water loss and produces less shrivel and stem desiccation. In more ventilated bags the RH will be lower, increasing transpiration and moisture loss from the grapes – therefore, less dehydration of stems and weight loss.

Temperature, especially higher temperatures and temperature rising during storage, may influence the quality maintenance of table grapes. Dr Fourie explained that temperature spikes during cold storage relate to increased respiration. The increase in metabolic processes may differ in liners of varying perforated areas – this being why SO₂ release and packaging cannot be viewed separately.

Milestones and optimised guidelines

Dr Den Breeyen said that post-research, the researchers could make suggestions (rather than being too prescriptive) about what packaging combination growers could use under different pre- or post-harvest conditions. She noted that solutions need to be tailored for each specific scenario.

Dr Fourie observed that the final objective of this study would be the guidelines produced at the end of the project that needed to be reasonably broad. In summary, it should educate growers, highlight gaps in their current practices, and help them understand precisely where to apply this knowledge to optimise their packaging solutions.

Guidelines for optimal post-harvest packaging to limit decay in table grapes

This document provides practical recommendations for the post-harvest handling and packaging of table grapes, with the primary objective of reducing decay, extending storage life, and maintaining fruit quality during storage and transport.

It is intended for growers, packhouse operators, exporters and supply chain stakeholders. The document also outlines the key factors influencing post-harvest deterioration in table grapes, including moisture loss, fungal decay (particularly *Botrytis cinerea*), temperature fluctuations, cultivar, and mechanical damage. It translates current scientific knowledge and industry best practices into actionable recommendations. Central to the guidelines is the optimisation of packaging combinations.

The guidelines address pre-cooling requirements and cold chain management, handling practices to minimise mechanical injury, as well as sustainability considerations, including recyclable and biodegradable packaging options.

The knowledge product includes decision-support tools, visual diagrams of packaging configurations, and comparative insights to help stakeholders choose the most suitable packaging strategies for their specific operational contexts.

Packaging and handling decisions should not be left to chance. They need to be guided by the precision of scientific evidence.



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Project team: Daniël Viljoen
Dr Johan Fourie
Dr Alana Den Breeyen

Implementing institution: ExperiCo -
Agri-Research Solutions

Involved institution: South African Table Grape Industry (SATI)

Author Imogen Campbell