Mitigation Technologies for Sanitary and Phytosanitary Compliance

Can't breathe, can't breed

Chemicals are no longer fruit producers' only defense against pests. By creating conditions under which no insect can survive, new treatments are green and lethal.

FRUIT-PRODUCING COUNTRIES that supply phytosanitary markets have to make sure that fruit is all they export. The risk of introducing insect pests into countries where they do not occur naturally has to be avoided. In this quest, pre-harvest measures such as orchard sanitation are important, but post-harvest mitigation treatments are critical.

Since the 1930s, methyl bromide fumigation has been used worldwide as a broad-spectrum and fast-acting mitigation treatment. However, scientists have since discovered that methyl bromide depletes the ozone and in 1992 a global phase-out plan was launched. As of 2005, developed countries were banned from using the product. Developing countries, including South Africa, received an extension and are permitted to use methyl bromide for quarantine purposes until 2015.

1 Dr Shelley Johnson.
2 While the core temperature of the fruit is monitored, the air around the fruit reaches a maximum of 40°C. One objective of this project is to determine how the heat impacts the ripening of fruit. Another is to establish whether the most opportune time to treat fruit destined for the export market is, in fact, just before cold storage.

In addition to this looming deadline, the South African fresh fruit export industry is under increasing international pressure to reduce its general use of chemicals. Alternatives that are currently being explored include irradiation and treatments that combine extreme temperatures with modified controlled atmosphere. Irradiation is a processing technique that exposes food to electron beams, X-rays or gamma rays. The process produces a similar effect to pasteurisation, cooking or other forms of heat treatment, but with less effect on look and texture.

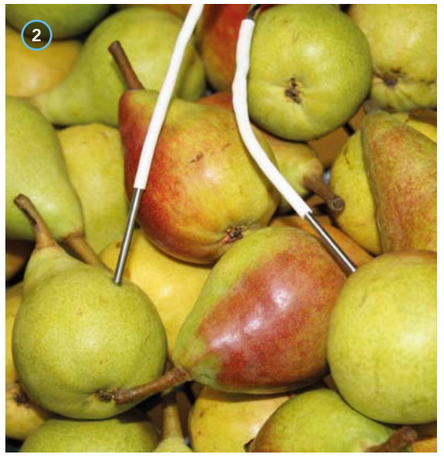
KNOCKOUT COMBINATION

A combination treatment that is now becoming available in South Africa, is known as controlled atmosphere temperature treatment system, or CATTS. It combines two stresses to kill insects, namely heat and an atmosphere with low oxygen and raised carbon dioxide levels that impair breathing.

Dr Shelley Johnson, who works for HORTGRO[Science], is currently leading a new project that evaluates the viability of this environmentally friendly post-harvest mitigation treatment. Her research is focused on the control of three prominent South African phytosanitary insect species, namely false codling moth, banded fruit weevil and grain chinch bug. Stone and pome fruit varieties were selected for the trials. Trials will also be conducted for citrus and subtropical fruit.

The cornerstone of the project is a laboratory-sized CATTS unit, supplied by Techni-Systems in the USA. The Post-Harvest Innovation Programme financed the purchase of the unit and HORTGRO[Science] funded a Techni-Systems technician to install the machine and train the research team on its use and maintenance. The CATTS unit arrived in South Africa in July 2013 and was installed at the Department of Conservation, Ecology and Entomology of Stellenbosch University, where Dr Johnson is based as a research associate.

Dr Johnson first became aware of CATTS technology while researching alternative phytosanitary treatments. She contacted Dr Lisa Neven, the research entomologist at the United States Department of Agriculture (USDA) Agricultural Research Service (ARS) in Washington State, who led the team that developed the first CATTS unit on a laboratory scale, for help. Their collaboration has since seen the publication of two scientific articles in the *Journal of Economic Entomology*. Dr Johnson recently visited Dr Neven to investigate the large-scale CATTS treatments that are now available thanks to the use of a commercial unit with two-ton chambers.



THE CATTS STORY

CATTS technology was developed by the United States Department of Agriculture (USDA) Agricultural Research Service (ARS) in Washington State, after experimentation with thermal treatments in combination with controlled atmosphere (CA). Forced-air is used at high temperature and the CA environment is made up of low oxygen levels and raised carbon dioxide levels.

Despite the success of the two-pronged treatment, the initial tests took very long to complete, especially with infested fruit. To hasten the process and avoid the expense of in-fruit treatments, the USDA-ARS researchers replaced the forced-air with hot water. The result was the controlled atmosphere water bath (CAWB). A large number of insects can be tested with the CAWB and it can indicate the heat tolerance and potential response of insects to CATTS.

Post-harvest treatments have been developed in the USA to control codling moth and western cherry fruit fly in cherries, and codling moth and oriental fruit moth in apples, peaches and nectarines. Fruit quality evaluations have shown that these treatments are not detrimental to fruit marketability.

CATTS treatments are now listed in the USDA-APHIS (Animal and Plant Health Inspection Service) Quarantine Treatment Manual, specifically approved for the control of insect pests in fruit exported from the USA.

PROJECT TITLE
Controlled Atmosphere Temperature Treatment System (CATTS) as a post-harvest treatment for phytosanitary pests of deciduous fruit

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DURATION
Twenty-seven months

PHI-2 CONTRIBUTION
R400 000

LEAD INSTITUTION
HORTGRO[Science] and Stellenbosch University (Department of Conservation, Ecology and Entomology)

BENEFICIARY
The citrus, deciduous and subtropical fruit industries

FOCUS AREA
Mitigation technologies for sanitary and phytosanitary compliance

HUMAN CAPITAL DEVELOPMENT
One MSc student

Mitigation Technologies for Sanitary and Phytosanitary Compliance

> "The advantage of CATTS as a combination treatment is that it kills insects faster and the reduced treatment times help to maintain fruit quality."
> Dr Shelley Johnson

THE RESEARCH PROCESS

In preparation for the South African CATTS project, the research team conducted preliminary studies in warm fruit baths to evaluate the effect of heated controlled atmosphere post-harvest treatments on key phytosanitary insect pests in the South African deciduous fruit industry, and to determine for which species CATTS technology is a feasible post-harvest mitigation option. The preliminary water bath studies focused on false codling moth, banded fruit weevil and grain chinch bug. Tests were conducted on adult banded fruit weevil and grain chinch bug, while different larval and egg stages of false codling moth were used. The temperatures and duration of thermal treatments needed to kill the pest species, were recorded.

A post-graduate student is currently testing the responses of fruit fly and mealybug to water bath treatments. Test temperatures range between 23°C and 45°C.

With the arrival of the CATTS unit, studies can now be carried out on infested fruit. Tests are repeated on false codling moth, banded fruit weevil and grain chinch bug, fruit flies and mealybugs to confirm treatment times and efficacy, and evaluate fruit quality after treatment.


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In terms of the controlled atmosphere part of the treatment, Dr Johnson uses 1% oxygen, 15% CO_2 and nitrogen as the balance, in the current study.

"Heat is obviously an issue with fruit quality," says Dr Johnson. "The question is what the high temperatures will do to the fruit, even though intense heat will not necessarily be applied for a long period. The challenge is to find an ideal balance between heating rate and duration."

To help answer these questions, fruit quality tests will be conducted in collaboration with the Department of Horticultural Science of Stellenbosch University in the final phase of the project. In order to properly establish the effect of the treatment on the fruit, the intention is to use larger fruit quantities than the water bath system could accommodate.

"If our study proves that CATTS treatments can successfully control South African quarantine pests without impacting negatively on fruit quality, it is likely that a commercial CATTS unit will be manufactured in South Africa," says Dr Johnson.

It is not difficult to engineer, since the main difference between a laboratory-scale unit and a commercial model is the size of the chamber. The simplicity of the engineering, however, does not detract from the major contribution that commercial-scale CATTS treatments can make to South Africa's access to phytosanitary export markets.


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1 The controlled atmosphere temperature treatment system (CATTS) combines two stresses to kill insects, namely heat and a modified atmosphere with low oxygen and raised carbon dioxide levels that impair breathing.
2 From the top: a false codling moth; a grain chinch bug; a long-tailed mealybug.
3 The modified atmosphere inside the CATTS unit is created by combining carbon dioxide, nitrogen and air. Nitrogen controls the concentration of O_2, which causes respiratory stress in the insects. Turning up the heat while lowering oxygen levels makes breathing impossible for insects.