# A combination that makes all the difference

Cold protocol treatments and irradiation are recognised phytosanitary treatments in their own right. Combining them, however, can revolutionise South Africa's citrus export industry.

**SMALL AS THEY** are, insect larvae are a massive hurdle in the fresh fruit export industry. Because larvae present the possibility of a quarantine pest establishing a population in the importing country, infested fruit consignments are rejected. Efforts to minimise and control infestations are therefore ongoing.

The cold protocol treatment is the post-harvest treatment most widely used to prevent the export of South African citrus fruit with live false codling moth (FCM) larvae. However, the current protocol of 22 to 24 days at -0,6°C is detrimental to fruit quality and often causes chilling injury.

Ionising irradiation has long been known to be effective in sterilising and killing pests in fruit. As far back as October 2002, the United States Animal and Plant Health Inspection Service (APHIS) approved irradiation as a quarantine treatment for fruit and vegetables at a generic dose of 150Gy for fruit fly (Tephritidae) and 400Gy for all other pests, including FCM.

Studies by Citrus Research International (CRI), however, have shown that, at these doses, irradiation is not an option as a stand-alone treatment as it causes prohibitive external quality losses. South African researchers have therefore joined the ongoing international effort to develop additional phytosanitary irradiation treatments and reduce the generic dose of 400Gy for FCM.

In recent times, new developments in phytosanitary regulations have opened up alternative options for the use of irradiation, namely combination treatments and sterile insect technology.

The former combines irradiation and cold treatments, both at reduced doses, and has been proven to suppress larvae and their successive development stages more effectively than the individual treatments alone. Probit-9 level efficacy was achieved with 60Gy of ionising radiation followed by cold exposure for 16 days at 2,5°C.

Sterile insect technology, or low-dose irradiation, affects the fecundity and fertility of pests, also resulting in Probit-9 mortality.

**1** Paul Cronjé.
**2&3** Irradiation damage on oranges and lemons.

## FAST FACTS

- Food irradiation is permitted by more than 60 countries.
- About 500 000 metric tonnes of food is irradiated annually worldwide.
- NASA astronauts eat meat that has been sterilised by irradiation to avoid getting food-borne illnesses in space.

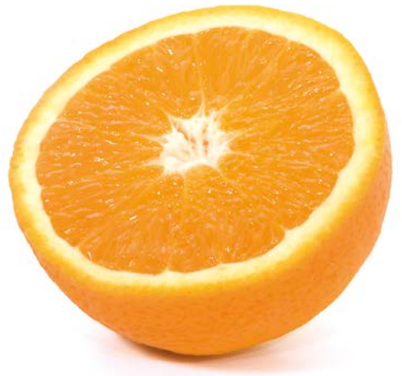
## Towards a new protocol

In 2014, Dr Paul Cronjé, a researcher at CRI, initiated a project funded by industry and the PHI Programme to establish a new disinfestation protocol for South African citrus, based on the potential of combined treatments. The first two steps towards this goal had already been completed by CRI entomological researchers, namely determining insect response to the lowest efficacy dose and to the combination of irradiation and cold treatment.

What remained to be determined was the maximum irradiation doses that could be tolerated by the major citrus fruit types exported by South African producers. Given that irradiation is not distributed evenly through a pallet of fruit, some of the fruit is exposed to doses twice or three times the minimum required dosage.

"We need the maximum and minimum values to determine if irradiating a specific cultivar group at a dosage that will be determined by the importing country is actually viable and will not lead to fruit quality losses," explains Paul. "In addition, we wanted to determine the effect on fruit quality of a combination treatment."

With this rationale in mind, Paul designed a study with two objectives:



1. Determine the threshold for fruit quality when irradiating various citrus types, namely, 'Clementine' mandarin, lemon, grapefruit, and Navel and Valencia oranges.
2. Determine variation in dose within each carton box (dosimetry study).

Working at the HEPRO facility in Cape Town, Paul and Jade North subjected eight pallets of different citrus fruit cultivars to gamma irradiation at 200, 300, 400 and 500Gy. Afterwards, the fruit was cold stored at 2°C or 7°C for 40 or 60 days, and then evaluated for internal and external quality.

The first group of fruit, harvested from May to early June, consisted of 'Nules Clementine' mandarin, 'Nova' mandarin, 'Washington' Navel, 'Eureka' lemon and 'Star Ruby' grapefruit. The second group, harvested in August, included 'Eureka' lemon, 'Navelate' Navel, 'Nadorcott' mandarin, and 'Turkey' and 'Midnight' Valencia orange.

For the dosimetry studies, and to confirm treatment levels of irradiation, a dosimeter was placed outside and inside the short wall, inside the long wall, centrally at the top, and at the middle and bottom of each carton.

## Results and recommendations

In terms of external quality, the researchers found that 'Nova' mandarin and 'Turkey'

**PROJECT TITLE**
Effect of irradiation levels on internal and external citrus fruit quality

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**DURATION**
Two years

**PHI PROGRAMME & INDUSTRY CONTRIBUTIONS**
R590 352 & R560 352

**LEAD INSTITUTION**
Citrus Research International (Pty) Ltd

**BENEFICIARY**
The citrus fruit industry

**FOCUS AREA**
Post-harvest physiology and post-harvest disease and insect control, including phyto-sanitary compliance

**PUBLICATIONS**
Pending

**PRESENTATIONS AND PAPERS**
One

Valencia oranges were highly sensitive, only tolerating doses of up to 200Gy. 'Nadorcott' mandarins and the lemons could tolerate doses below 300Gy. 'Nules Clementine' mandarin and the Navel oranges remained unaffected up to 400Gy, while 'Star Ruby' grapefruit and 'Midnight' Valencia oranges were the least sensitive, tolerating doses of up to 500Gy.

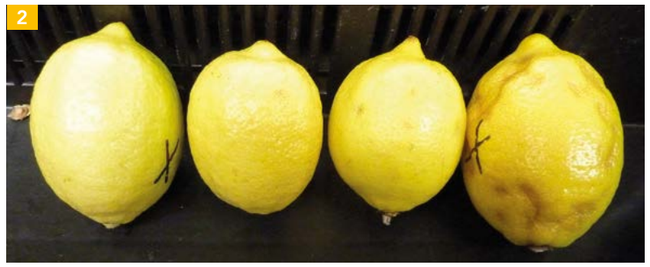
As far as internal quality is concerned, the expert taste panel could not identify the fruit exposed to 500Gy in any of the cultivars. "We could therefore confidently conclude that taste is not a commercial problem," says Paul.

The only internal quality parameter that showed any impact was a reduction in citric acid in the highly sensitive 'Turkey' Valencia and the 'Eureka' lemon, a high acidic cultivar.

The researchers concluded that there was a low incidence of disorders in the 200–300Gy range, combined with cold-storage at 2°C.

"We now know that compliance with combination treatments is indeed possible," says Paul. "Additional analysis will indicate if our data can be used to motivate a new combined protocol."

**1** Laboratory technician, Jade North, measures citric acid levels of citrus juice to determine the effects of treatments on juice quality.
**2** Increase in severity of irradiation damage in lemon fruit.
**3** Rind damage seen in Navel orange fruit due to irradiation.
**4** Rind collapse of 'Turkey' Valencia orange.



## FRUIT IRRADIATION …

- is a technology to extend the shelf life of fruit and eliminate insects,
- does not leave residue and does not make fruit radioactive,
- does not compromise the fruit's nutritional quality, and
- can change the texture or appearance of fruit by impacting rind quality.

## WHAT IS PROBIT-9?

Probit-9 mortality is a standard for treatment effectiveness that has its origin in fruit fly research, and has been adopted by the United States Department of Agriculture for fruit flies and several other pests.

## HOW DOES IRRADIATION WORK?

Irradiation disrupts the DNA molecules in the cell of an organism, making it impossible for the cell to replicate. As a result, the organism becomes sterile and/or dies.





## THE SCIENCE THAT IS FOOD IRRADIATION

Irradiation is a technology that improves the safety and extends the shelf life of food by reducing or eliminating micro-organisms and insects. Like pasteurising milk and canning fruits and vegetables, irradiation can make food safer for the consumer.

In South Africa, irradiation technology has been used for the control of food-borne disease since the 1960s.

Under the blanket statement of making food safer, irradiation can serve many purposes:

- Prevent food-borne illness by effectively eliminating organisms such as Salmonella and *Escherichia coli* (*E.coli*).
- Preserve food by destroying or inactivating organisms that cause spoilage and decomposition, and thereby extending the shelf life of foods.
- Offer phytosanitary applications by sterilising insects in or on fresh produce that is exported globally.
- Increase longevity by delaying sprouting (eg. in garlic) and ripening of fruit.
- Sterilise food intended for hospital patients with severely impaired immune systems, such as people with Aids or those undergoing chemotherapy. Foods that are sterilised are exposed to substantially higher levels of irradiation than levels approved for general use.

Food that has been irradiated carries the Radura logo and/or it is stated on the packaging "Treated with radiation" or "Treated by irradiation" or "Radurised".

Bulk foods, such as fruit and vegetables, must be individually labelled or a label has to be shown next to the container in which they are displayed.

It is important to remember that irradiation is not a replacement for proper food handling practices by producers, processors and consumers. Irradiated foods need to be stored, handled and cooked in the same way as non-irradiated foods, as they could still become contaminated with disease-causing organisms if the rules of basic food safety are not followed.

The safety of food that has been irradiated is undeniable. The technology has been endorsed by eminent global bodies, including the World Health Organization (WHO), the Food and Drug Administration (FDA), the Centre for Disease Control and Prevention (CDC), and the US Department of Agriculture (USDA).

Scientists agree that irradiation does not make food radioactive, compromise nutritional quality, or noticeably change the taste, texture, or appearance of food. Studies have furthermore shown that there is no significant loss of nutrients after food has been irradiated. Only small amounts of some vitamins are lost, similar to the amounts lost during other food processing methods such as refrigeration, canning and drying.