# EFFECT OF GAMMA IRRADIATION AS A MITIGATION TREATMENT ON STORAGE QUALITY OF PLUMS

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## Introduction

Export of fruit from South Africa to certain countries, such as the USA, requires a mandatory cold-sterilisation period of 22 days at -0.55°C or below, to disinfest fruit from phytosanitary pests, such as Mediterranean fruit fly. Since certain plum cultivars require a dual-temperature regime to maintain postharvest quality during cold storage, it is not possible to export such cultivars to markets with strict phytosanitary regulations.

Irradiation is a mitigation treatment approved by the Animal and Plant Health Inspection Services (APHIS) in USA for use on different fruit kinds, including plums from South Africa. Irradiation as a technology to disinfest plum was first evaluated on Songold and Laetitia by Taylor & Brock (1998). It was necessary to elaborate on this initial research, since storage regimes and packaging has subsequently changed, and SmartFresh$^{SM}$ has been commercialized for use on Songold plums, which enables better maintenance of fruit quality (De Kock & Taylor, 2010). Previous irradiation research on Songold and Laetitia plums (Taylor & Brock, 1998), reported that radurization may increase gel breakdown and lower flesh firmness at certain absorbed dose levels. Irradiation of table grapes, apples and pears has also been studied, with generally acceptable fruit quality attained after cold storage, dependant on the dosage rate applied (Witbooi & Taylor, 2008).

This communication provides an update on the irradiation research conducted on plums in 2010. It is important to keep stone fruit producers and exporters informed in this regard, since commercial use of irradiation for export to USA is likely to become an available option for certain plum cultivars in the near future.

## Materials and methods

Mini pallets of plums comprising 9 layers of cartons each were irradiated using Cobalt-60 as source, to determine the Minimum : Maximum (Min : Max) absorbed dose ratio across the pallet stack. Fruit packed in 400 x 300 mm cartons were sourced from a pack-house, transported to Hepro Cape (Pty) Ltd and irradiated at a dosage of ± 3000 Gy. Dosimeters were placed inside and outside cartons located in different positions on the mini pallet and the Min : Max absorbed irradiation dose ratio was determined. Mini pallets as opposed to standard height pallets were a necessity since there is a door height restriction at the irradiation facility.

In a second trial, Songold plums harvested and packed into 400 x 300 mm cartons lined with a perforated outer bag (54 x 2 mm grape bag), were sourced from a commercial pack-house in the Western Cape, South Africa. The mean flesh firmness and total soluble solids content of the plums at intake was 6.9 kg and 16.2%, respectively. Forty cartons of plums were equally divided into two groups, one treated with SmartFresh$^{SM}$ and the other not, prior to irradiation of both groups. All fruit were cooled to -0.5°C and where applicable, SmartFresh$^{SM}$ was applied after 5 days at -0.5°C. Both the SmartFresh$^{SM}$ and non-SmartFresh$^{SM}$ treated Songold plums were stored for a further 7 days at -0.5°C and then transported unrefrigerated from ExperiCo to the irradiation facility (duration of ± 45 min.). The SmartFresh$^{SM}$ and non-SmartFresh$^{SM}$ treated plums were subjected to identical irradiation dosages, which commenced ± 20 minutes after arrival at the irradiation facility. For each treatment, dosimeters were placed inside three of five cartons of plums stacked in a single column, to determine the minimum absorbed dose, while two dosimeters were placed on the outside of the cartons to measure the maximum absorbed irradiation dose. Five cartons of SmartFresh$^{SM}$ and non-SmartFresh$^{SM}$ treated plums were not subjected to irradiation, while five cartons each of the remaining fruit were subjected to three irradiation treatments, comprising target dose levels of 400, 600 and 800 Gy. Five cartons each of SmartFresh$^{SM}$ and non-SmartFresh$^{SM}$ treated plums per dosage rate were simultaneously exposed to gamma radiation from the cobalt-60 source. Each carton constituted a single replicate. Following irradiation, the plums were transported back to ExperiCo, and cold stored for a total of 42 days. Non-SmartFresh$^{SM}$ plums were held for 10 days at -0.5°C, followed by 10 days at 7.5°C and 22 days at -0.5°C, while SmartFresh$^{SM}$ treated plums were stored for 10 days at -0.5°C, 18 days at 7.5°C and 14 days at -0.5°C. Fruit quality was assessed at the end of the 42 days cold storage period, as well as after a subsequent shelf life of 5 days at 10°C. Flesh firmness, total soluble solids, titratable malic acid, decay, shrivel and internal disorders (gel breakdown, internal browning and overripeness) were measured to provide an indication of fruit quality as it would be experienced by consumers. Flesh firmness was measured on one cheek of 10 fruit per carton using a penetrometer fitted with an 11 mm plunger. Decay and shrivel was quantified as the percentage fruit exhibiting a particular disorder per carton, while the percentage internal disorders were calculated by cutting and twisting 20 fruit per carton to enable visual

examination of the mesocarp. Fruit quality data at the end of cold storage and after shelf life were subjected to one-way ANOVA to determine treatment differences.

## Results and discussion

In the dose mapping trial, the Min : Max absorbed irradiation dose ratios between the center and outside of cartons in the middle and bottom layers of the mini pallet of plums were below or close to the maximum target ratio of 2.5 (Figure 1). The top layer exhibited a Min : Max absorbed irradiation dose ratio of ± 2.7, just above the maximum permitted ratio. However, the average Min : Max dose ratio of ± 2.3 across the three layers, fell within the ratio requirement. The Min : Max ratio of 2.5 is important, since APHIS stipulates that the minimum absorbed dose must be above 400 Gy, while the maximum must never exceed 1000 Gy.

In the Songold plum quality trial, irradiation data indicated that all treatments were irradiated within a Min : Max irradiation dose ratio of 1.8 (Figure 2). Fruit irradiated to a target dose of 400 Gy received a minimum absorbed irradiation dose of ± 357 Gy, slightly below the permitted minimum absorbed irradiation dose of 400 Gy, but the maximum absorbed dose was ± 600 Gy. Fruit irradiated at a target dosage of 800 Gy received a minimum and maximum absorbed irradiation dose of ± 740 and ±1160 Gy, respectively, the latter which is above the permitted maximum. Fruit irradiated at a target dosage of 600 Gy received a minimum and maximum absorbed dose of ± 600 and ± 840 Gy, respectively. This data indicated that for the evaluation of both SmartFresh$^{SM}$ and irradiation on fruit quality, a good range of radiation doses had been obtained.

Fruit quality evaluation of Songold plums after cold storage and after shelf life indicated that generally, irradiated plums had a lower flesh firmness than plums not subjected to irradiation (Figure 3). Irradiated and non-irradiated SmartFresh$^{SM}$ treated plums were consistently firmer than plums not subjected to SmartFresh$^{SM}$ and in most cases, this difference was significant (not shown). Flesh firmness decreased during shelf life, irrespective of whether treated with SmartFresh$^{SM}$ or not. At the end of shelf life, SmartFresh$^{SM}$ plums irradiated at a target dose of 800 Gy exhibited a flesh firmness of approximately 2 kg, while non-SmartFresh$^{SM}$ fruit were too soft for commercial purposes, with a flesh firmness of 1 kg.

Songold plums not treated with SmartFresh$^{SM}$ before irradiation developed high levels of gel breakdown after shelf life, compared to those treated with SmartFresh$^{SM}$ (Figure 4). Albeit not significant, after shelf life data suggested that even with SmartFresh$^{SM}$, the tendency for gel breakdown increases at higher irradiation dosage rates. Apart from gel breakdown, the internal fruit quality of fruit from all treatments was acceptable after cold storage. This data suggests that for successful export of irradiated Songold plums, it will be essential to use SmartFresh$^{SM}$ to control the development of internal disorders. Albeit not significant, gel breakdown and

overripeness may be exacerbated in Songold plums if irradiated at the higher dosage of approximately 800 Gy and hence, the risk without using SmartFresh$^{SM}$ is too high.

Songold plums not treated with SmartFresh$^{SM}$ exhibited higher levels of shrivel after 6w cold storage, before shelf life, than fruit treated with SmartFresh$^{SM}$ before irradiation (Figure 5). However, over the shelf life period, this situation changed, with levels of shrivel decreasing in non-SmartFresh$^{SM}$ treated plums and increasing in SmartFresh$^{SM}$ treated fruit. This can be ascribed to the fact that bags were opened at the start of shelf life, therefore no longer controlling moisture loss, as well as the fact that the non- SmartFresh$^{SM}$ treated plums ripened more rapidly. The latter is known to reduce shrivel symptoms, and it is speculated that as cell membranes become more permeable with ripening, cell fluids are released into the intra-cellular regions of the flesh tissue, thereby reversing shrivel symptoms. Generally, higher irradiation dosages were associated with higher levels of shrivel. Decay, TSS and acid levels were not affected by the irradiation or SmartFresh$^{SM}$ treatments (data not shown).


**Figure 1 :** Min. and Max. absorbed irradiation levels (Gy) and Min : Max ratio values recorded at various positions in mini pallets of plums packed in 400 x 300 mm cartons, following irradiation with $Co^{60+}$

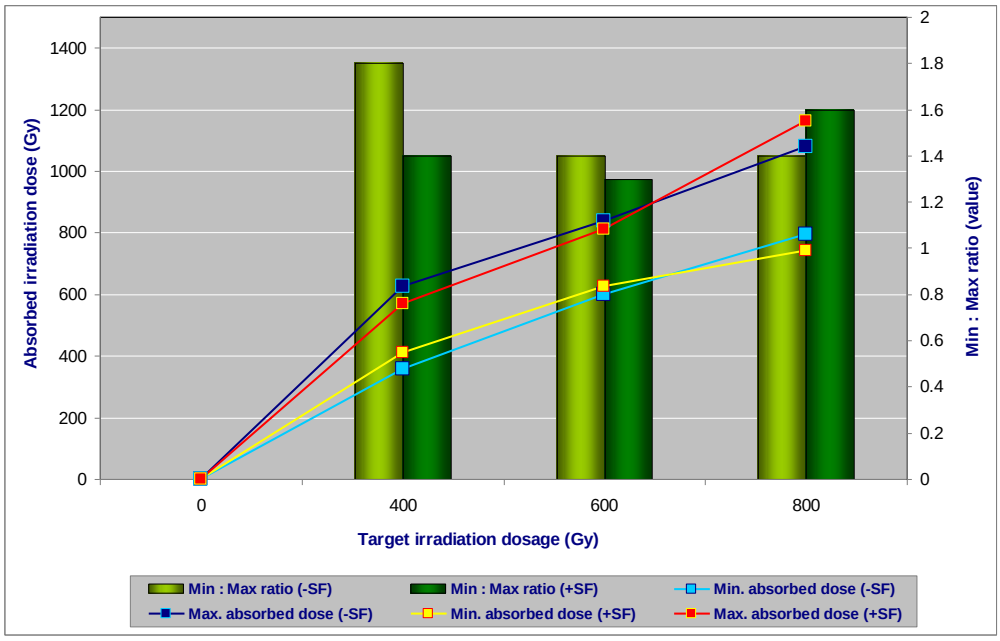


**Figure 2 :** Min. and Max. absorbed irradiation levels (Gy) and Min : Max ratio values for Songold plums, treated with SmartFresh$^{SM}$ (+SF) or left untreated (-SF) before irradiation of single columns of 400 x 300 mm cartons with $Co^{60+}$ at a target dosage of 400, 600 and 800 Gy

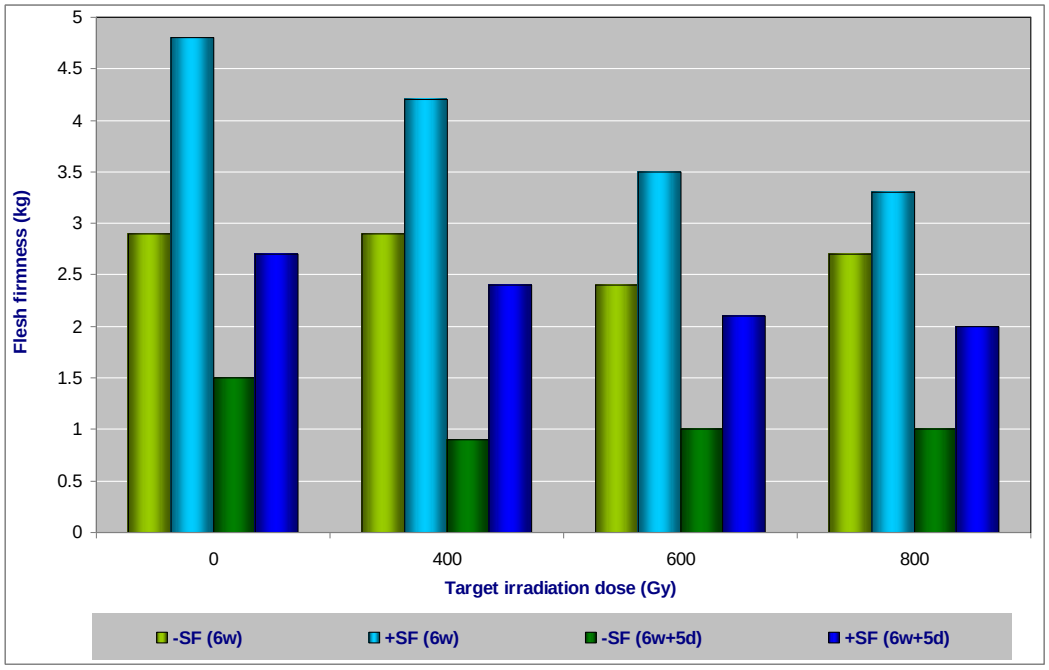


**Figure 3 :** Flesh firmness of Songold plums, treated with SmartFresh[SM] (+SF) or left untreated (-SF) before irradiation at 400, 600 and 800 Gy, after dual-temperature storage for 6w and 6w + 5d at 10°C

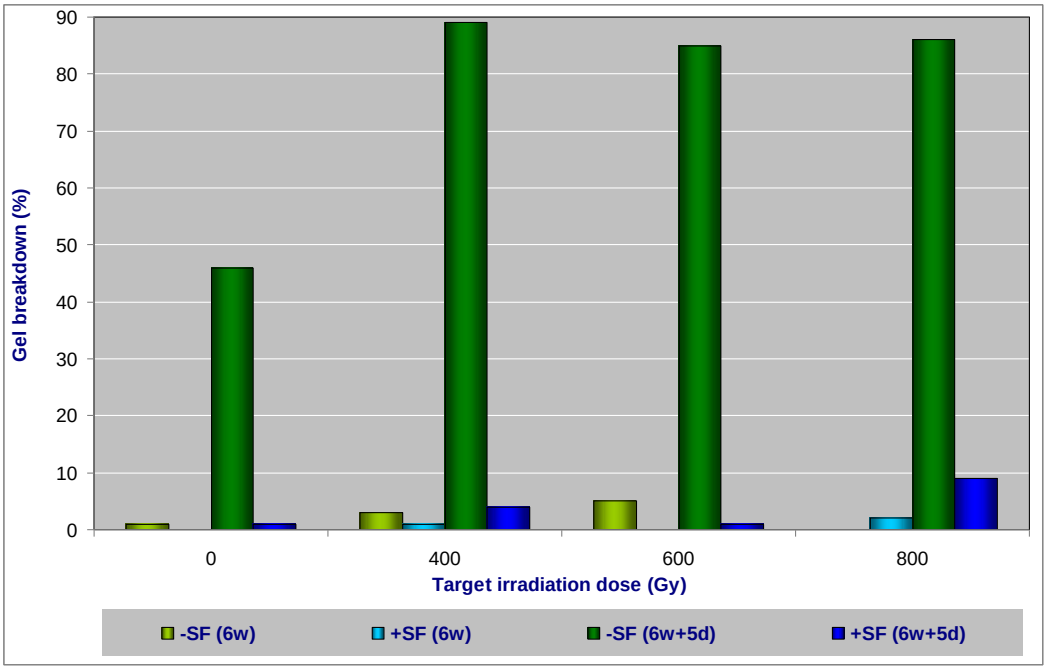


**Figure 4 :** Gel breakdown in Songold plums treated with SmartFresh[SM] (+SF), or left untreated (-SF) before irradiation at 400, 600 and 800 Gy, after dual-temperature storage for 6w and 6w + 5d at 10°C

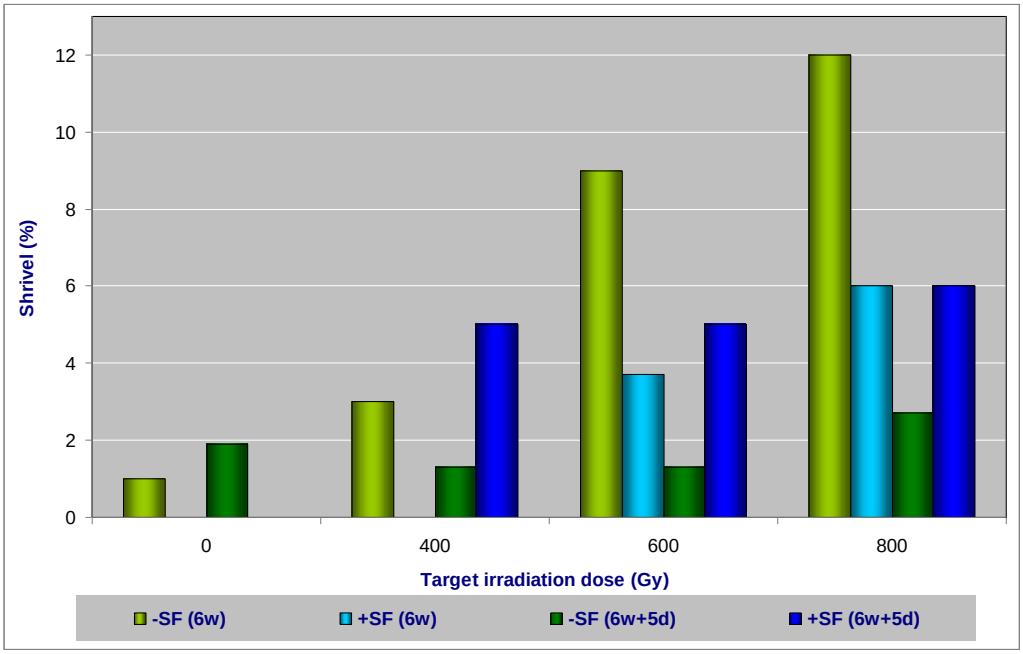


**Figure 5 :** Shrivel in Songold plums treated with SmartFresh$^{SM}$ (+SF), or left untreated (-SF) before irradiation at 400, 600 and 800 Gy, after dual-temperature storage for 6w and 6w + 5d at 10°C

## Conclusion

The dosimetry on mini-pallets of plums indicated that the Min : Max ratio needs to be further improved to ensure that a 2.5 ratio is not exceeded. The irradiation service provider will need to explore means of achieving this. SmartFresh$^{SM}$ treatment of Songold plums prior to irradiation was shown to be vital for maintaining quality during cold storage. Flesh firmness tended to decrease with an increase in the absorbed irradiation dose. However, the decrease in firmness was acceptably minimized by use of SmartFresh$^{SM}$. Songold plums not treated with SmartFresh$^{SM}$ exhibited serious gel breakdown, regardless of the irradiation dose. Shrivel levels were higher on Songold plums treated at the higher irradiation dosage, compared to plums treated at lower irradiation levels. Collectively, this research suggests that subject to achievement of permissible Min : Max ratio's, commercial export of irradiated Songold plums will be possible, on condition SmartFresh$^{SM}$ is applied.

## References

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