Fruit Waste Management for Queensland Fruit Fly Prevention

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- In the fight against Queensland Fruit Fly (QFF) and other fruit pests and diseases, the effective management of fruit waste is an essential quality assurance measure
- For successful QFF management and control, a suite of management tools including baiting, monitoring, netting, cover sprays if applicable, and other hygiene measures, all need to be in play, area wide

Fruit waste is an inevitable part of commercial fruit production. In the fight against Queensland Fruit Fly (QFF) and other fruit pests and diseases, the effective management of fruit waste is an essential quality assurance measure, yet it is often a practice that is overlooked or under-rated as it is thought to not be directly associated with money in the bank, or is it?

QFF best management practice involves applying a suite of tools, each tool enhancing the value of the other tools used, meaning more likelihood of fruit in the box and money in the bank.

It's a given that growers aim to reduce or not produce "waste", as "waste" does not pay the bills, and it costs time and money to deal with. However, "waste" does occur. Ideally, growers look for a market for "saleable waste" e.g. freezing or processing fruit, and a use for "waste" that at least negates the cost of handling for disposal, e.g. feeding of livestock.

All works well (cost-wise) if these options are available locally (within an affordable distance from production system), and if the end user sees value in the product. This is only a part solution, as there is still unusable or inedible waste to deal with, and there is still the issue of increased unusable waste if there's a fruit glut, extreme weather damage or if there is a biosecurity concern with the fruit. This project focused on what can be done with "waste", specifically already containerised "packing shed waste" and/or "field waste", damaged and unsaleable, intentionally collected and removed from the production area (best practice).

Trade protocol requirements for the prevention and management of QFF and for the reassurance of QFF absence in a production system, states fruit waste must be removed from the accredited production property. This is supported by general production best practice highlighting the importance of the removal or reduction of harboured waste for the on-going management of most other pests and diseases.

For those without a use for waste fruit, it can be managed with a commercial waste collection service for a hefty fee, a cost burden for producers, and smaller producers may find it is infrequently collected. Alternatively, it could end up dumped on-farm, as far away from the production area as possible. Smaller farms that are more likely "land poor" due to the increased need for production area lack sites away from their current crop to dump waste, and if and when it is dumped, it could be in an open area (not a deep pit that is covered each day as per best practice recommendations), or end up in the paddock next to the dam or neighbour's crop. Either scenario can result in the harbouring of pest and disease in sitting fruit that can contribute to the next generation of pests such as for QFF.

Larger production systems may be able to navigate around this by absorbing waste collection fees, or more regular waste pick-ups. Some large enterprises have been able to address waste management by dedicating a cool room to freezing and treating fruit waste before dumping on their property or at an alternative location. Some larger enterprises with regular packing days have developed relationships with regular users of fruit waste, a sustainable option due to the regularity of supply into the end point use. However, smaller scale producers can struggle with the regularity, time, cost and options for waste management and disposal.

The project investigated options for sustainable, practical and affordable waste treatment options on-farm that could likely be adopted by small enterprises to minimise QFF risk. Other benefits of the research outcomes are for the management of other pests and diseases, and to validate the international research on fermentation for Spotted Winged Drosophila (SWD) management, should the pest ever reach Australia.

Project Roadmap

Box Hill Institute (BHI) Biosecurity Centre of Excellence initially undertook a scoping study, producing a literature review of current fruit waste management practices such as augmentoria, heat treatment, destruction and desiccation, deep burial, cold storage and fermentation. Considering the risk of pest escape associated with a break in the barrier of the augmentoria, the cost of applying heat or chill treatment to fruit waste, the safety hazards and impracticality of rotary hoeing and deep burial methods, and the issues of storing sound fruit in a cool room in the proximity of waste fruit (if only one cool room operates), it was deemed that fermentation was likely the most affordable, practical and sustainable practice for destruction of waste fruit to investigate.

This was supported by use of the practice in the United Kingdom for SWD management where management focuses on controlling the SWD population at several points of the fruit production season. Low SWD numbers at the end of a fruit season correlate to the low pressure of the SWD population at the start of a new season or at the start of a subsequent crop in the same season.

Waste treatment is one of the management methods employed and involves containerising the waste fruit using a waterproof membrane in a standard fruit bin and locking fruit away under fermentation conditions for several days, then disposing of the end product (Noble & Dobrovin-Pennington, 2016).

BHI's literature review was then accompanied by a small laboratory trial to increase confidence that the practice of fermentation would also sufficiently kill QFF eggs and larvae in high-risk fruit (collected waste).

Factors thought to affect fermentation or contribute to larval and egg death are temperature, oxygen reduction (or lack of O_2), carbon dioxide increase (or high CO_2 concentration), alcohol production, and possibly pH decrease. The UK studies indicate the mechanism is CO_2 saturation and the deprivation of O_2 to the pest in the treatment container.

Temperature

This was not a focus of this study as heat/cold options already exist for 'treatment' of fruit. Instead, temperature was recorded to observe ideal conditions for fermentation.

O_2 reduction/ CO_2 production

The reduction in oxygen is thought to be a key factor in larval death, however, it is hard to measure. Instead, the increased CO_2 production is easy to observe. The mechanic of drowning is also an action that reduces O_2 availability to larvae in the fruit pulp and fermentation environment.

Alcohol & Sugar

The accumulation of alcohol could possibly cause larval death, and can be easily measured on-farm with a refractometer to measure sugar and calculations performed to determine the specific gravity.

pH

Fruit is acidic in general and it was not determined in the literature review if pH had an effect on larval death. In the laboratory test, pH observations were made to gain an appreciation of fermentation conditions.

Laboratory Trial

In BHI's experiment, class one strawberries and raspberries were infested with QFF eggs (under laboratory conditions at NSW DPI) and then placed in both control (untouched) and trial (fermentation) conditions in the BHI laboratory soon after infestation.

The following images and results summary has been provided by Blake (2019) in the "Fruit Waste Management for QFF – Scoping study" report for publication here, and can be read in full at: studentweb.bhtafe.edu.au/course/view.php?id=16970

Fruit pulp samples from the trial and the control were taken at daily intervals and placed in rearing out conditions where any surviving larvae were allowed to pupate and emerge into adult QFF. Results of the trial indicated some key observations;

- 100% QFF egg and larval death after fruit pulp was kept for a minimum of 2 days in the fermentation trial conditions.
- QFF larval survival was recorded from samples taken at the 7-10 day mark from the "control" (fruit left undisturbed and exposed to O_2 as if it were dumped in the paddock).

Figures 1–3. Berries being infested with QFF eggs and confirmation of infestation of eggs (cross sectional view of an infested strawberry). Photo credit: Box Hill Institute, Biosecurity Centre of Excellence.

The following is an excerpt from the "Fruit Waste Management for QFF —Scoping study" report:

Raspberries

Flies emerged from raspberry control samples taken from the first four days of sampling (Figure 4). On average about 3 flies emerged from duplicate samples taken over this period. No flies were observed to emerge from control samples taken after 4 days. No flies were observed to emerge from samples taken from fermentation vessels at any time.

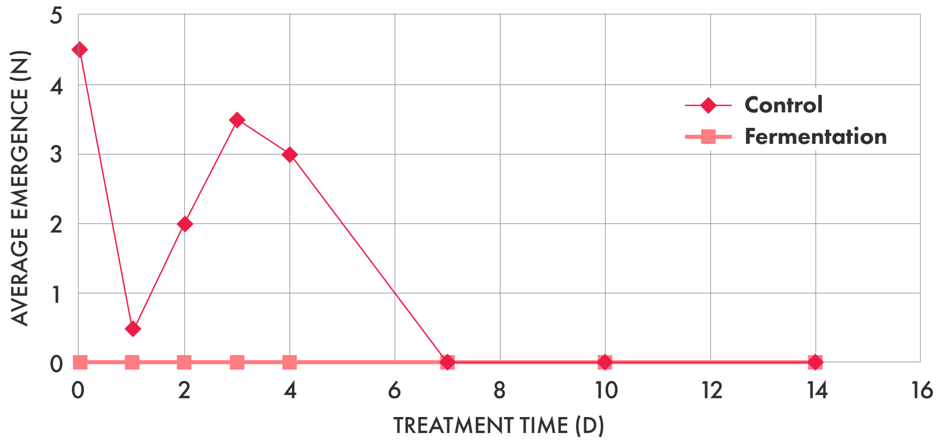

Figure 4. Effect of fermentation treatment on *B. tryoni* flies emerging from duplicate raspberry samples. Graph depicting number of QFF to emerge from raspberry fruit pulp samples taken on x days from the trial and control start.
Source: Box Hill Institute, Biosecurity Centre of Excellence

Strawberries

Flies emerged from strawberry control samples taken from the first 7 days of sampling (Figure 5). On average about 6 flies emerged from duplicate control samples taken over this period. No flies were observed to emerge from control samples taken after 7 days. Flies emerged from strawberry samples taken from the fermentation vessels at time zero and at day 1. No flies were observed to emerge in fermentation samples taken after day 1.

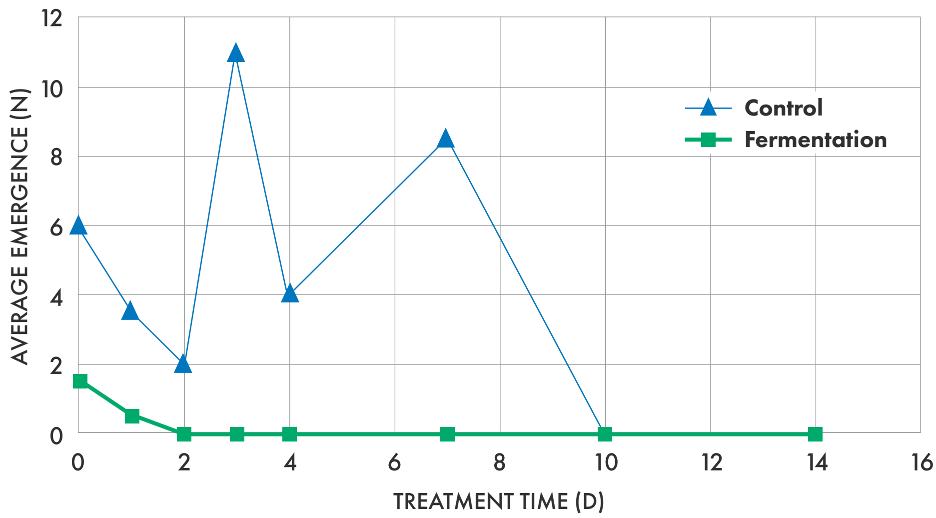

Figure 5. Effect of fermentation treatment on *B. tryoni* flies emerging from duplicate strawberry samples. Graph depicting number of QFF to emerge from strawberry fruit pulp samples taken on x days from the trial and control start.
Source: Box Hill Institute, Biosecurity Centre of Excellence

The initial observations from the laboratory experiment were that QFF larval death occurred in the fermentation conditions in the laboratory environment. Further questions arose from the study:

- What fermentation parameters caused larval death?
- What fermentation parameters can be easily achieved on-farm?
- What parameters can be measured easily in practice to give confidence to decision making of when the ferment is safe to release on-farm?
- How tolerant will the process be of environmental changes such as temperature, time, type and maturity of contents added, and size or shape of vessel used?
- Will producers find this option practical or sustainable?
- Will producers apply the measure to effectively reduce risk of QFF survival on-farm?
- Will trade partners have confidence and approve of the practice as being equivalent to 'removal from accredited property'?

Production System Trials

Fermentation of fruit was trialled at 10 Yarra Valley fruit growing sites during the Autumn of 2022. For the trials, the fermentation vessels were upscaled to 60L vats with screw top lids. Carbon dioxide bubblers (release valves), thermometers and drainage outlets were fitted to each vat. Two vats (for cycling batches of fruit waste) were fixed to a standard pallet for ease of handling, transport and storage at packing sheds (Figure 6).

A range of fruit was trialled at varying maturities, including strawberries, blackberries and raspberries, figs and plums, depending on the participant's fruit waste load at the time. In addition to temperature tracking, visual fruit and CO_2 observations were made by the participants, and in addition Brix was measured by the Project Manager during visits (although it was not able to be measured as frequently as the barrels were emptied on various days). (Figures 7-10)

Field trial results included the observation of a range of ferment times occurring – both shorter and more extended cycles than initially expected, yet all were longer than the laboratory trial suggested as needed.

Figure 6. Fermentation vessels set up for use on-farm.
Photo credit: Michael Edwards

A wide and varied temperature range was recorded inside the vats (corresponding with typical day and night fluctuation, and if the vat was stored in or out of the sun). In all cases, participants all considered that the fruit looked and smelled fermented before they emptied the vats into the field. One site instantly upsized to 200L vats to accommodate for their expected volume of waste fruit.

Project Manager observations of the vat use across the 10 sites included issues such as a cycle of ferment not completed due to a lid not secured properly, overflow of waste fruit stored in open barrels due to the fermentation trial vat being too small and ferment taking too long because fruit was not degrading well (likely under-ripe fruit and too firm), instructions provided not understood by all staff (including some staff that were not in direct communication with the Project Manager), and occasions when the vats were infrequently emptied due to lack of participant's available time.

Figures 7-10. Fruit in the fermentation vessels at various stages of fermentation. Photos credit: Michael Edwards

Feedback from the participants was positive and all participants were willing to take the practice on again next season. Participant feedback was the primary goal of this trial as well as trialling methods for seamless integration into the production system.

Participants suggested improvements such as:

- adding yeast to accelerate the ferment
- emptying the vats only partially, and leaving a starter culture in the vat to assist fermenting the next batch (appeared to accelerate the stage it was trialled)
- increasing the number of barrels to have more ferments on the go at once (particularly in cooler weather when ferment is slower)
- using larger vessels to cope with volume gluts, and to reduce the frequency of emptying, (acknowledging the need to fill and lockdown still)
- adding water to increase the degradation of fruit (especially firmer fruit)
- adding an agitation device to assist with the breakdown of the fruit to aid fermentation
- finding a more efficient method of disposing of the fermented product out of the vat, such as an automated process or a pipe with a pump that could be triggered to turn on when needed (to avoid a person and vehicle taking the pulp away from the shed)

Figure 11. Taking the ferment away from the packhouse for disposal on-farm (confident that it carries no pest risk).
Photo credit: Michael Edwards

Participants were generally happy the process was low cost and easy to set up and very likely to be adopted into the current production system activities.

It is noted that Participants have asked about:

- The fermented fruit disposal onto the paddock. What are the effects of the fermented product on the soil (nutrification), on animals that ate it, and on the microbes and life in the soil where it is dumped? This may or may not differ to the practice of dumping fruit in the paddock, but it will differ when compared to removal of waste to stockfeed or alike.
- Determining if the larval/egg kill parameters could be defined further, e.g. creating a process that required less measurements to be taken. One participant requested a monitor be developed that could sit in the lid and track all the parameters associated with a complete and successful ferment, that is then able to emit a green light when ready to dump (sufficient ferment to kill the eggs and larvae). One participant asked if just a visual cue based on the condition of the fruit pulp could be sufficient.

Overall, it is important to note that the project considered the treatment of containerised waste only and focussed on solutions for small production systems (not trying to replicate treatment options already established). This does not remove the risk of QFF potentially in damaged or unharvested fruit left in the production area, an issue that is a massive contributor to supporting QFF populations in a region.

For successful QFF management and control, a suite of management tools including baiting, monitoring, netting, cover sprays if applicable, and other hygiene measures, all need to be in play, area wide. Treatment of containerised waste is only one tool in the toolbox.

Future

The project goal for the fermentation process was to deal with WASTE, not anything saleable. Selling or moving on is always the preferred option (but sales and livestock consumption are not guaranteed - volume and need can vary). Producers need an option that can be upscaled quickly and with items on hand at a given point in the season.

Knowing and practicing the "how to" and "requirements of a setup" is a key asset that can assist producers in being able to pivot quickly into upscaled fermenting practices. Ideally, it would be good to have the design and criteria published for producers to use and have the confidence in the in-field practices successfully eliminating QFF (and potentially SWD) larvae and eggs in suspect or high-risk fruit.

If possible, it would be good to define a singular parameter of QFF larvae death and only measure for this, e.g. this may simply be CO_2 concentration or O_2 deprivation. It is likely that we will see producers aim to upscale again into 1000L vessels. However, more investigation will be required to refine the process to a point that interstate trade partners are content with this as a suitable and acceptable option for management of waste in accredited production systems.

Acknowledgements:

The following people helped with various stages of planning, research, and trials for these projects: Dr Solomon Balagawi and the staff at DPI New South Wales (Ourimbah); Dr David Williams, Agriculture Victoria; Agriculture Victoria – project funding and guidance; Box Hill Institute, Biosecurity Centre of Excellence team of Mick Blake, Tina Gilbertson, Lauren Turner and Sahar Eid for the literature review and laboratory trial; Yarra Valley Fruit Growers for trialling and reviewing the process; and Michael Edwards for managing the farm trials.

References

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