

Better postharvest handling for Samoan smallholder farmers



A practical guide

Steven JR Underhill

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Printed by Westminster Printing

First published January 2017

Cover and layout designed by Annette Vandermaat

Editing and proofing by Julie Lloyd Consulting

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National Library of Australia Cataloguing-in-Publication entry:

Underhill, Steven JR, 1965 – author.

A practical guide to better postharvest handling for Samoan smallholder farmers

ISBN: 978-0-9954431-0-5 (paperback)

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FOREWORD

Smallholder fruit and vegetable farmers are critical to Samoa's agricultural sector, and to the country's wider food and nutritional security. To support our farmers, there has been significant and ongoing technical and extension assistance to help them overcome daily production challenges.

However, simply growing quality produce is not enough. Fruit and vegetables must be harvested, transported and marketed so that food safety is ensured, produce quality and nutrition are retained, and potential postharvest losses are minimised. Often, the difference between a farmer making a profit versus making only a small return is determined by the final steps between farm and consumer.

The importance of good postharvest handling practice is clearly identified in our Government's recently-released Agriculture Sector Plan (ASP) 2016–2020.

Broadly speaking, the quality of Samoa's horticultural products needs to improve for our farmers to be competitive in domestic and export markets. Moreover, in response to the new Food Safety Act, it is essential that the integrity and safety of horticultural value chains is closely addressed.

Like many agricultural sectors across the globe, our agricultural sectors operate within multi-institutional and multi-organisational environments. Coordination between these environments is vital. Through close partnerships, current and future challenges can be resolved.

It is therefore appropriate that this book was developed as a result of the close support and assistance of staff from Scientific Research Organisation of Samoa (SROS), The Ministry of Agriculture and Fisheries (MAF), The Food and Agriculture Organization (FAO) of the United Nations, Samoa Agriculture Competitiveness Enhancement Project (SACEP), Australian Centre for International Agricultural Research (ACIAR), Samoa Farmers Association (SFA), Samoa Chamber of Commerce and Industry (CCI), the University of the Sunshine Coast and The University of Queensland (both in Australia).

While many challenges experienced by our farmers are similar to those experienced across the Pacific, this book has been written specifically for Samoan farmers. It draws on invaluable real-life examples from farmers across Samoa, and as such, is long overdue.

I am pleased to present and endorse this book as an important publication in support of Samoan smallholder fruit and vegetable farmers. I believe it will make an important contribution to revitalising and enhancing our horticultural productivity.



Hon Laaulialemaletoa Asiata
Leuatea P.f. Von Schmidt.

Minister of Agriculture and
Fisheries and Scientific Research
Organisation Of Samoa

Hon La'aulialemaletoa Asiata Leuatea P.F. Von Schmidt



MINISTER OF AGRICULTURE AND FISHERIES
& SCIENTIFIC RESEARCH ORGANISATION OF SAMOA

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Prof Underhill gained his PhD in 1993 from UQ in tropical postharvest horticulture. Prof Underhill has worked in tropical postharvest handling research in support of smallholder farmers throughout South-East (SE) Asia and the South Pacific since 1988.

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Acknowledgement

A practical guide to assist Samoan smallholder farmers was funded by the Food and Agriculture Organisation of the United Nations (FAO). The author would also like to acknowledge additional funding from the Australian Government through the Australian Centre for International Agricultural Research (ACIAR) which supported wider postharvest research and development in the Pacific region, the findings of which are also presented in this book.

The invaluable assistance and support provided by Mr Shukrullah Sherzad and Dr Tim Matryn (FAO); the staff of the Scientific Research Organisation of Samoa - Dr Seeseei Molimau-Samasoni, Tuimaseve Kuinimeri Finau and Semua Militini Tagoai; and research and extension officers from the Ministry of Agriculture and Fisheries (MAF) particularly Tilafono David Hunter. The author would also like to thank the valuable input from Mr A J Cowley, Ms Johanna Coyle, Mr Edwin Tamasese, Grant Percival and the Samoan Farmers Association.



TABLE OF CONTENTS

INTRODUCTION	6
Fit-for-purpose postharvest handling solutions	7
Getting it right ... better returns and safer food	9
ON-FARM PRACTICES	11
On-farm practices that influence product quality	11
Harvesting	12
Harvesting equipment that assists best practice	13
Harvest with care and avoid produce damage	17
Harvesting techniques for improved food safety	19
In-field transport options that improve efficiency	22
In-field storage for fresher produce	26
Sorting and grading	29
On-farm grading for better results	29
In-market grading techniques to reduce losses	31
Washing	34
Ice-wash baths - hydrocooling	38
Packaging	40
Packaging for perishable crops	41
Packaging for less-perishable crops	42
On-farm ripening and storage	48
Good ripening practices	48
TRANSPORT	51
Transport practices and reducing losses	52
Transporting by open truck	53
Roadside pick up	55
Consignment loading	56
Transport practices for food safety	59
Reducing the risk of in-transit damage	60
Common problems and how to fix them	62
Loose on-farm loading of crops	63
Inefficient loading and unloading practices due to the wrong packaging	64
STORAGE	65
Storage hints to maintain freshness	66
Cool-storage hygiene	68
Storage temperatures for fruits and vegetables grown in Samoa	69
REFERENCES	71
FURTHER READING	72
CLOSING COMMENTS	75

INTRODUCTION

This book aims to provide practical advice and strategies to help Samoan smallholder farmers, transporters and vendors to improve postharvest horticultural quality, reduce postharvest loss, and ensure food safety.

Samoan horticultural value chains incur moderate levels of postharvest loss. In a recent survey of commercial-scale and smallholder farmer postharvest horticultural losses in Samoa, postharvest loss was shown to be between 10 to 15% (Underhill, *et al.*, 2016).

While these figures may not sound dramatic, there is considerable variability in the levels of postharvest losses. For example, the central municipal market in Apia and the Salelologa market on Savaii have higher losses compared to the smaller privately-owned roadside markets. Farmers in the more rural parts of Upolu and Savaii experience higher and more unpredictable levels of postharvest losses, whereas farmers involved in direct selling and contractual farming often have negligible losses.

Postharvest losses are higher in fruits than vegetables. Some crops, such as soursop, Tahitian limes, papaya, mustard cabbage, bok choy, choko and avocado, are particularly vulnerable to high levels of loss.

Additionally, postharvest handling is more than simply reducing direct losses. Compromised food safety is another significant cause for concern. Unsafe horticultural product is food that cannot be consumed due to microbial or chemical contamination, and which should be removed from the food chain. Ensuring freshness is an issue in Samoa. While horticultural products are generally sold within a few days, it is still quite common for products to be stored and displayed for four to five days, potentially reducing food safety and nutritional value.

Nationally, Samoa has unclear horticultural food safety compliance standards. Most horticultural harvesting, transport and handling practices carry a level of food safety risk. In 2015, a preliminary food safety survey by the Scientific Research Organisation in Samoa gave grounds for concern, with around half of the assessed horticultural value chains found to have detectable microbial food safety contamination. **Hence, this book also aims to provide strategies to improve horticultural food safety compliance.**

Throughout this book, **the focus is on nil or low-cost postharvest remediation strategies compatible and applicable to Samoa's horticultural production systems.** Information is based on numerous postharvest studies by the book's Author of smallholder and community-based horticultural production systems in Samoa and across the South

'Throughout this book, the focus is on nil or low-cost postharvest remediation strategies compatible and applicable to Samoa's horticultural production systems.'

Pacific. Importantly, this book presents a range of simple and practical ideas developed by Pacific smallholder farmers. Maintaining quality and reducing losses is a universal challenge. Many farmers and vendors across the South Pacific have come up with their own solutions, some of the best of which are presented in this book.

It should be noted that **the author has deliberately avoided recommending or promoting the use of postharvest chemicals.** This is for several reasons. Although the responsible and appropriate use of postharvest chemicals is central to most horticultural value chains in Australian and New Zealand, this is coupled with extensive chemical legislation, work health and safety compliance auditing and independent residue testing. In the South Pacific, where it is difficult to identify and enforce safety and compliance, to advocate wider use of chemicals within the food chain may create more problems than resolutions.

There has also been considerable effort by the Pacific Organic and Ethical Trade Community (POETcom), the Samoan Government, Women in Business Development and Samoa Organics to support greater adoption of organic production systems in the region. To advocate for postharvest chemicals would undermine this significant effort.

Ultimately, if simple yet highly-effective postharvest handling practices, and good farm hygiene practices can be adopted, the need for postharvest chemicals is significantly reduced.

Finally, in providing practical postharvest handling recommendations, it is important to adopt a pragmatic approach given **implementing 'ideal' postharvest handling systems is not always possible or practical.** In Samoa, as in much of the South Pacific region, it is often difficult to access: farm labour, reliable and affordable cool storage infrastructure and equipment, and reliable transport. Packing costs can be too high, and wider social, cultural and religious obligations impact on time. These factors often necessitate adopting a 'third-best or fourth-best' approach to postharvest handling. With this in mind, **strategies to minimise the potential adverse impacts of unavoidable poor handling practices are also presented.**

FIT-FOR-PURPOSE POSTHARVEST HANDLING SOLUTIONS

Much of the international literature on improving postharvest handling by smallholder farmers often seeks to promote technologies that are common practice in developed economies. While there is little doubt strategies, such as refrigerated storage and transport, cardboard and plastic packaging, or use of postharvest chemicals, will reduce postharvest losses, many of these solutions are inaccessible to smallholder farmers in the

South Pacific. They are also potentially incompatible with existing value chains or may create adverse, unforeseen impacts.

Access to postharvest refrigerated storage and transport in the South Pacific is limited to large-scale farmers or traders involved in contract selling, those supplying the export market, or commercial importers. For the vast majority of smallholder farmers and vendors, product is stored, transported and marketed under ambient conditions. In Samoa, this means temperatures between 25°C and 30°C. The majority of the existing horticultural value chains in the South Pacific tend to be configured to limit on-farm storage, involve daily or fast-to-market transport logistics, and preferably rapid on-selling at the municipal markets.

In Samoa, where horticultural cool chains are a rarity, supply logistics are fast and relatively efficient, there is surprisingly little in-transit loss. Short transport distances and comparative small production volumes negate the potential adverse consequences of limited access to cool-chain infrastructure. But there is little room for error or unforeseen delay in such an approach, and when things do go wrong, losses are disproportionately high. Advocating greater adoption of cool-chain management is a common but rarely-successful solution. High running and maintenance costs, limited perceived benefit amongst smallholder farmers, and inequitable farmer access, have consistently impeded wider adoption. Veit (2009) in his review of the limited success of community-placed cool rooms in Fiji provides a detailed account of the complexities of establishing and ensuring sustainable cool-chain capacity.

'.....when things do go wrong, losses are disproportionately high.'

The current reality, at least in the short-to-medium term, is that to improve postharvest handling of horticultural crops in Samoa, **the focus needs to be on identifying ways to make the current ambient temperature-management chains more efficient and predictable**, less prone to human error, and more resilient.

Poor packaging is also a common problem across the South Pacific. While there are a range of simple postharvest packaging options available to farmers and vendors, it is often hard to identify the best solution and adoption strategies. Cardboard cartons, the international standard in packaging, often do not perform well under tropical conditions, quickly deteriorate when wet, or if packed with wet product. Plastic field crates are very expensive in the Pacific, sometimes difficult to source, prone to theft and rarely come in uniform sizes, making multiple commodity consignment loading difficult. Wooden cartons, while probably not a first-choice selection, are cheap and easy to construct, but are rarely used by Samoan farmers.

'What works elsewhere may not necessarily work well in the South Pacific.'

Much of the horticulture product sold in Samoa is packed in locally-made weaved baskets or large recycled sacks. What is the 'best' packaging comes down to what is available to the smallholder farmers, cost and suitability to existing postharvest handling practices. Obviously, packaging needs to be selected based on capacity to maintain product quality, affordability for growers, and environmental impacts.

GETTING IT RIGHT ... BETTER RETURNS AND SAFER FOOD

Ultimately, all efforts to improve postharvest across the board are of little to no value if they do not benefit smallholder farmers and vendors economically.

The introduction of most new pieces of postharvest technology or new practices come at a financial and/or time cost. Unless this translates into some form of economic benefit (higher prices, lower labour costs, or reduced losses) there is a real risk it might actually reduce net-farmer profitability. However, it is important to realise that benefits might not be immediately evident. Improved postharvest handling systems can increase consumer demand based on perceived quality, freshness or food safety, improve supply predictability, enhance market reputation, and potentially increase access to high-value domestic markets.

Food safety is also an important part of the equation and compliance to Government regulations. **The Food Act 2015 No 16**, administered by the Samoan Ministry of Health, presents an important dimension to horticultural value chains. The Act states the legal obligation for farmers and vendors to ensure food safety compliance. While adoption of postharvest handling practices to improve quality and reduce losses is a commercial decision, the adoption of safe food handling practices is a legal requirement.

This book outlines how industry can achieve these ends through better postharvest strategies specifically for Samoa. The postharvest handling practices outlined are designed to achieve short-term or medium-term benefit for farmers, vendors or consumers, and to enable improved food safety compliance.

'The aims of fit-for-purpose postharvest handling are to improve profitability, reduce inconsistent supply, and importantly, ensure the product is safe to eat.'





ON-FARM PRACTICES

ON-FARM PRACTICES THAT INFLUENCE PRODUCT QUALITY

How fruits and vegetables are grown and handled have profound effects on their quality and storage life.

The cultivar selected, how and where it is planted, whether the crop is irrigated or rain-fed, the type and nature and frequency of pesticide and fungicide application, the type of fertilizer that is used (inorganic or animal manures), whether crops are grown with trellising, under protective structures or in the open field, all collectively influence quality, and in many cases, how long product can be stored.

The first decision a farmer makes with postharvest quality and storage life implications is the cultivar type or species planted. Sometimes high postharvest losses and poor product quality cannot be overcome, simply because the cultivar selected is not suited to the local conditions.

When seeking to improve postharvest quality in Samoa, it is important to appreciate that production practices across the region are rarely ideal. Limited availability of suitable land, poor access to good quality seed (especially during mass replanting following adverse weather events), the high cost of chemical and other farm inputs, and unreliable access to farm labour, are unfortunately the norm in the South Pacific.

Inefficient or poor production practices can also be a deliberate business decision. There are strong commercial incentives for farmers to grow out of season to access high market prices, or seek to lower production and handling input costs in response to low retail price.

By definition, postharvest handling practices commence from the point product is picked. When a product is harvested, all subsequent on-farm handling practices have the potential to adversely affect product quality, compromise food safety, influence nutritional value and determine how long a product can be stored.

On-farm practices which influence postharvest quality and losses include:

1. Harvesting
2. Grading and sorting
3. Washing
4. Packaging
5. On-farm ripening and storage

HARVESTING

The best time to harvest fruit and vegetables is in the early morning, when it is cool. Farmers in other, hot-climate countries sometimes harvest in the dark for this reason.

When product is harvested and kept cool, it can be stored for longer and will retain more of its nutrition. Warm product will not only rot faster, but any damage caused by subsequent poor handling will appear sooner and will tend to be more severe.

However, in practice, many smallholder farmers in Samoa tend to harvest throughout the day. Limited or unpredictable access to farm labour or a reliance on public buses to transport product to the market often necessitates the product being harvested, packed in the late afternoon, stored on-farm overnight, and transported to the market the following morning. This practice is very common among smallholder taro farmers who sell into the local markets.

If you need to harvest in the late afternoon:

- It is very important to store the crop in a cool shaded area after harvest.
- Avoid placing product in large heaps after harvest, as it will cool more slowly (and maybe even heat up).
- Delay packing. Once packed, product takes longer to cool.

Note – Harvesting in the later afternoon should be avoided for leafy vegetables and tree fruits.

- Leafy vegetables will heat up and cool down very quickly. Always pick in the morning and transport as soon as possible.
- Tree fruits, such as mango, avocado, citrus, papaya and soursop harvested in the late afternoon will quickly rot. If warm fruit are packed immediately after picking, the temperature in the carton can further increase.
- An ice-water bath or even cool (clean) water can be very effective in reducing the temperature. (See washing and hydrocooling)
- Larger product, such as watermelon and squash, take a lot longer to cool.

'When product is harvested and kept cool, it can be stored for longer and will retain more of its nutrition.'



Tomato farmers in Fiji have found that harvesting after 7am and before midday results in less postharvest losses. Harvesting too early in the morning, (before 7am) when the product is likely to be wet (dew), increases the chance of postharvest rots.



In some crops, harvesting after prolonged rain, or if product is wet, can increase the risk of damage. Fruit crops, especially soft-skinned fruits, will bruise more easily when picked after rain. Greater care is needed during harvesting, sorting and packing in the wet season. Harvesting citrus after rain can lead to the oil glands in the skin rupturing, causing damage to surface of the fruit. In mango, the sap ooze after harvest - which can damage the fruit - is more pronounced if fruit is harvested after rain.



(Above) This vegetable farmer in Alesia harvests from 7 to 9am. Due to local high humidity and frequent early-morning rain, product is often wet.

For leafy vegetables, harvesting wet product is not generally a problem. This practice can also provide some benefit in terms of reducing the rate of leaf wilt during transport to market.

HARVESTING EQUIPMENT THAT ASSISTS BEST PRACTICE

Harvesting process (i.e. the method used to pick the produce) is critical, as it is one of the major causes of physical damage to a crop. This is particularly the case in tree fruits (such as breadfruit, and mango) that are more prone to being dropped during harvesting.

Produce is often damaged by using the wrong harvesting method or by rough handling.

A recent study in Fiji showed that product harvested by hired farm labour often had more losses (31% postharvest loss) compared to when harvesting is undertaken by family members (20% postharvest loss) (Kumar, 2016).

One of the problems with poor harvesting is that the consequences are normally only visible after a few days. Taro dropped or thrown will develop injury bruising after three to four days. In other crops, such as limes and lemons, there may be no visual damage but the product can become more sensitive to subsequent poor handling.

One of the biggest issues is a general misunderstanding of what 'good harvesting practice' actually means.

- Always use clean knives and tools. Dirty knives and tools will result in rapid spread postharvest diseases.
- Avoid dropping the crop more than 30cm (less in some fruits).
- Hard, green fruit can damage as easily as soft fruits.

Sometimes it is best to use specialised harvesting equipment, especially with tree crops such as mango, breadfruit, citrus and papaya.

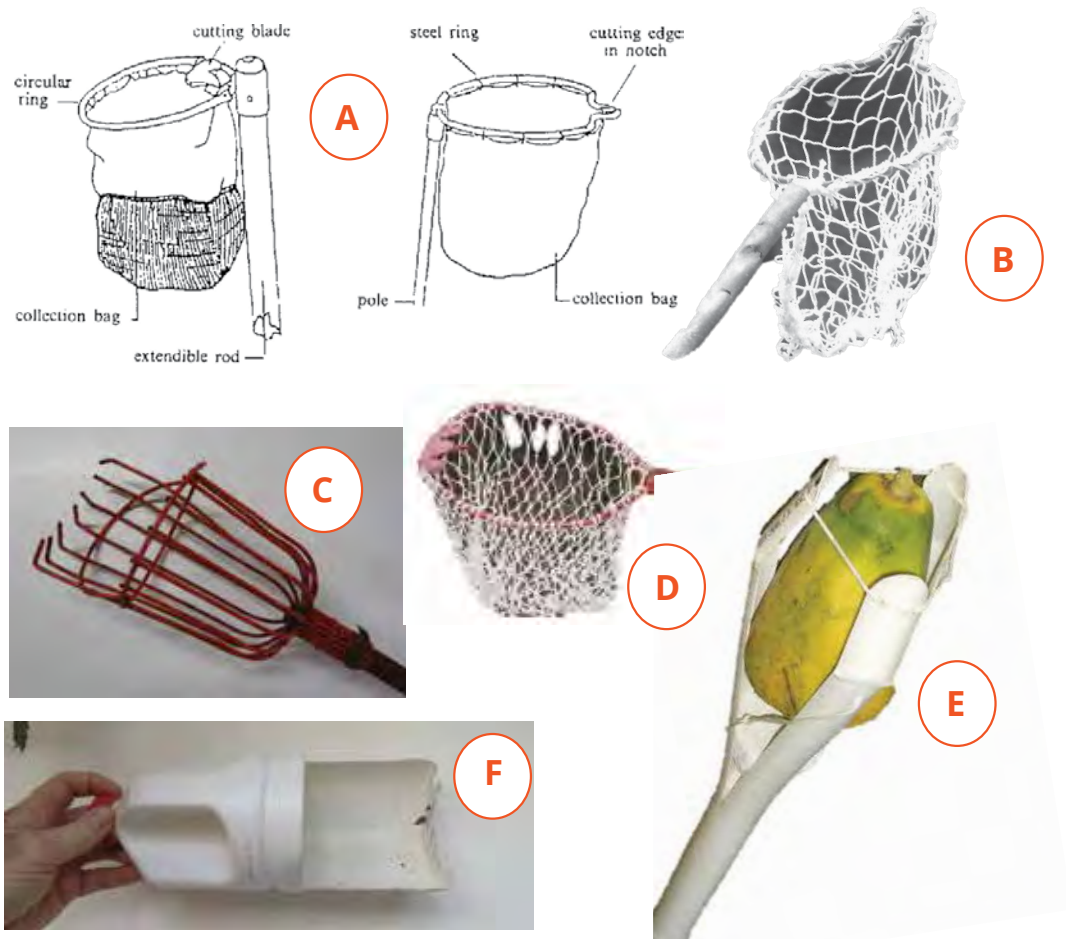


This picker is using a commercial picking pole to harvest limes.

'Sometimes it is best to use specialised harvesting equipment, especially with tree crops such as mango, breadfruit, citrus and papaya.'

While pruning poles are widely available in Samoa, they can be very expensive. An alternative is to simply make your own.

Some simple field-picking pole designs for tree fruits are shown below.



- A. Mesh/cloth picking pole. Source¹
- B. Small net attached to a pole. Note the groove at the end to detach fruit. Source²
- C. Wire cage picker with pole. This type of harvesting tool is available in some hardware shops in Apia .
- D. Net with a metal comb. Source³
- E. PVC pipe-picking tool. Made using a plastic water pipe, which has been cut to shape three prongs. Note the cord connecting two of the prongs and a second cord (not visible) attached to third prong to open and close the picker. Source⁴
- F. Home-made plastic bottle harvesting tool that is then attached to a long pole. NOTE the grooves cut in the base. Source⁴

¹ <http://www.fao.org/docrep/t0073e/T0073E07.htm>

² <http://ucce.ucdavis.edu/files/datastore/234-1450.pdf>

³ <http://vikaspedia.in/agriculture/post-harvest-technologies/technologies-for-agri-horti-crops/mango-harvester>

⁴ <http://cdn.instructables.com>

Harvesting tree fruits in Samoa normally involves climbing large trees. Of particular concern is the occasional practice of using children to pick mangoes and breadfruit. This is never recommended and comes with significant, adverse child-safety implications.

Gupta and Reeves, (2009), in one of the few studies of the implication of poor harvesting in the Pacific reported that there were 32 official hospital visitations in Lautoka, Fiji in 2008 due to falls from mango trees.

In a more extensive longitudinal study in the Solomon Islands, Negin et al., (2014) reported that between 1994 and 2011, there were 1107 people referred to the National Hospital in Honiara due to injuries associated with falls from trees. Of these, 85 per cent were less than 20 year-old males. Highlighting the specific risk to children in fruit harvesting, 77 per cent of the people with injuries associated with falling from guava trees were less than 10 years old.



An alternative to make harvesting easier and safer is to construct a simple wooden platform around large fruit trees. While not practical in larger-scale commercial tree orchards, such harvesting aids are suitable for small-tree or single-tree plantings, common throughout much of Samoa.

In the photograph below, a farmer in the Alesia region has built a platform around a large mango tree using recycled wooden pallets.



For fruits like breadfruit, pineapple and mango, it is better to ensure fruit are harvested with a short stem. In mangoes this will reduce sap flow, whereas in pineapple, leaving a small section of stem attached is thought to reduce the chance of rots and lessen the risk of in-transit bruising.



HARVEST WITH CARE AND AVOID PRODUCE DAMAGE

A key to careful harvesting is to avoid rough handling. Even heavy produce, such as taro, will develop internal bruising if handled roughly. Some Samoan taro farmers throw taro into piles on the side of the field to make it easier to collect. This will damage the taro. Because damage often only develops after the product has been sold at the markets and cannot be detected prior to cutting, most farmers are not aware rough handling causes damage.



Never throw produce. Even taro will easily bruise if handled roughly.



For some crops, such as leafy vegetables, careful harvesting is essential.

Crops mostly likely to experience poor or rough handling are hard-green product, (i.e. avocado) and root crops. It is incorrect to assume that less care is needed to harvest, pack and transport crops that are firm.

Rough handling is more common amongst hired labourers, when there are insufficient pickers, when picking is rushed, or when harvesting is not supervised.

One reason for rough handling is poor access within the field. A lack of pathways within the field makes the adoption of wheelbarrows and trolleys to transport produce impractical. Instead, farmers harvest the crop and throw it into small piles for subsequent collection. This is common in smallholder farms where taro is grown on hillsides.

If you construct simple pathways, align pathways across the slope so as to reduce the risk of subsequent erosion.



The photograph below shows a traditional taro farm near Tafagamanu (Lefaga Bay) highlighting the rough terrain and lack of internal field pathways.

As most leafy vegetables are grown in more cultivated and accessible farm plots, harvesting trolleys can be more easily adopted.



(Photograph opposite of a small holder vegetable farm near Leulumoega).

HARVESTING TECHNIQUES FOR IMPROVED FOOD SAFETY

Poor hygiene or inappropriate on-farm handling practices can lead to food contamination, creating a food safety risk for consumers. A 2015 survey of horticultural handling practices in Samoa, reported a significant number of vegetable farms were not compliant to the new Samoan Government Food Standards (Asora-Finau *et al.*, 2015).

While the application of good postharvest handling practice should always be promoted, it is effectively a business decision by individual smallholder farmers, based on likely return for effort. This is not the case when it comes to food safety.

In Samoa there is a legal requirement all fresh fruit and vegetables that are sold are safe to eat.

Avoid picking and placing product on the ground after picking. This can lead to product coming into contact with the soil and manures. It is best to pick and place straight into a field crate.



Don't place harvest product on the soil.



Better to place straight into field crates.

Make sure field crates, boxes and any surface that product comes into contact with have been cleaned beforehand.

Dirty field crates are a common cause of food safety contamination. They can also increase postharvest disease risks.

Wash field crates prior to use. Water or a disinfectant can be used to clean crates (1 to 2ml of household chlorine bleach in 1L this will give 100 to 200ppm).



It is just as important to make sure that the outside of crates is also cleaned.

Dirty crates, especially those with soil or grease (see photographs below) can lead to cross-contamination of other products during transport. They can also cross-contaminate sorting tables, cool rooms and storage areas.



(Above left) Soil and grease on the outside of crates will cross- contaminate cool rooms and trucks, increasing food safety risk. (Above right) Make sure any tarps or covers placed over the harvest product are clean, especially for leafy vegetables.

It is good practice to clean all plastic field crates at least once a week, making sure to clean in and outside.

Once cleaned, care should be taken to store the crates in a place or manner where they are likely to stay clean.

In the photograph below, a smallholder farmer in Alesia has adopted a good practice of hanging field crates up after use. Store field crates where they will stay clean. Be aware that wet crates will quickly get dirty if placed on the ground, so best to placed washed crates on a piece of clean cardboard or similar clean surface while left to dry.



If you use tarps or plastic to cover produce - a common practice to store produce overnight on farm prior to bus transport to market - it is important to make sure cover material is clean. This is especially important for leafy vegetables where dirty tarps can increase the risk food safety contamination. In some cases, it is better to use large leaves rather than heavy plastic tarps. Avoid using the same covering afterwards for general farm use.

The photograph to the right shows a breadfruit farm near Nofuoli'i where a dirty tarp was placed over the carton for short-term, on-farm storage. Because this product will be processed, this practice is less problematic. However, in terms of adopting good agricultural practice, this should still be avoided.



(Photography opposite) Make sure any tarps or covers placed over the harvest product are clean, especially for leafy vegetables.

Good postharvest farm hygiene is more than just keeping field crates and harvesting equipment clean. It is also important to keep livestock away from crops and ensure the farm is well maintained. The same goes for where harvesting equipment is stored after use. Always aim to store field crates undercover rather than in-the-field.

Remember, it does not need to look pretty, but it does need to be clean!



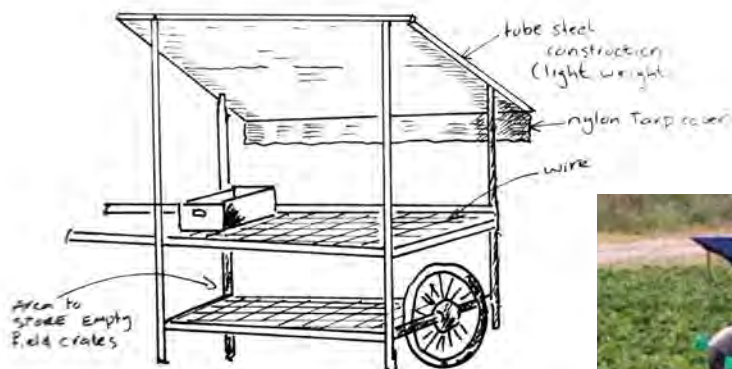
IN-FIELD TRANSPORT OPTIONS THAT IMPROVE EFFICIENCY

One consideration commonly overlooked when seeking to improve harvest practices is farm labour efficiencies and the use of in-field transport.

In the larger commercial farms throughout Samoa, you often see farm staff picking a small quantity of produce into a crate, then carry individual crates of the produce over to a truck, empty the field crates into a larger field bin, and return to the field to continue harvesting. This practice is time consuming and slow. Often, simply having more field crates available for pickers can speed up the harvesting process.

The mobile harvest trolley

An alternative and potentially more time efficient system is to construct a mobile harvest trolley. Made out of tubular steel with a cheap nylon or plastic tarp covers, trolleys allow pickers to harvest larger volumes of crop, removing the need to place the field crates on the ground (making it easier to keep them clean) and providing some shade to the product once harvested. This system is best suited to highly-perishable light-weight crops, such as tomato. An additional benefit of a mobile trolley is that it can also be used as a potential mobile roadside vendor stall.



Design considerations

- Larger wheel(s) will be easier to move in a muddy field.
- Use material that is light and cheap (such as galvanized fencing steel) to keep the weight down and reduces construction cost.
- Wire benches are preferable as they are easy to clean.
- Use a simple plastic tarp sheeting for shade.

For high-volume or heavy crops, consider using a range of commercially-available steel nursery trolleys. Or better still, design and construct your own. Farm trolleys can also make transport of produce from the farm to the road much easier, especially for female roadside market vendors.



Wheelbarrows and sledges

Wheelbarrows are widely used to transport heavy produce, such as taro and breadfruit by smallholder farmers throughout the South Pacific.

However, wheelbarrows are also used to transport lots of things, such as soil, fertilizer and manures - all high-risk sources of food contamination



If using a wheelbarrow to move product there are some important things to remember.

1. Make sure it is cleaned well before use.
2. Use fresh leaves or clean cardboard as a protective liner.
3. Remember, steel surfaces will heat up quickly if placed in the full sun. Best to place wheelbarrows in the shade prior to use.
4. If you have a few wheelbarrows, spray one a different colour and keep it specifically for harvesting.



Smallholder farmers in the Solomon Islands, Fiji and Vanuatu use a range of options, including locally- constructed sledges (opposite) which are pulled behind bullocks or horses.



Wooden field bins vs field crates

Larger-scale farms in Samoa sometimes use sizeable wooden field bins to harvest and transport produce. Field bins can create problems if there is limited capacity to unload the bins on arrival at the packing shed or markets. This can result in produce having to be unloaded and reloaded multiple times, which is labour and time intensive, and may damage produce in the process.

Field bins are not suitable for crops prone to damage, such as bok choy, which are better transported in field crates. For other crops, such as eggplant and breadfruit, smaller field crates are also preferable. Field crates are ideal for larger-volume produce, such as breadfruit for processing, fresh taro, pineapple and cabbage.



It is best to avoid using large field bins unless you have access to a forklift or pallet-jack to unload produce.



(Above) Large field bins are best avoided for crops that are easily damaged, such as leafy vegetables.

Below – loading into field bins is often done poorly (i.e. produce is often damaged). It is important to fill and empty the bins with care. As an alternative, use plastic field crates that require less repacking (loading and unloading) and are easier to handle and lift.



Below – locally-constructed, large field bins used by some commercial growers. Make sure there are no protruding screws or nails as these will damage produce and are a danger to farm staff.



IN-FIELD STORAGE FOR FRESHER PRODUCE

If produce needs to be held in the field after harvest for short periods (i.e. one to three hours) prior to sorting or packing, it must be placed in a cool, shaded area. The faster that harvested produce is moved into the shade, the better. This is particularly important for leafy vegetables, which wilt quickly.



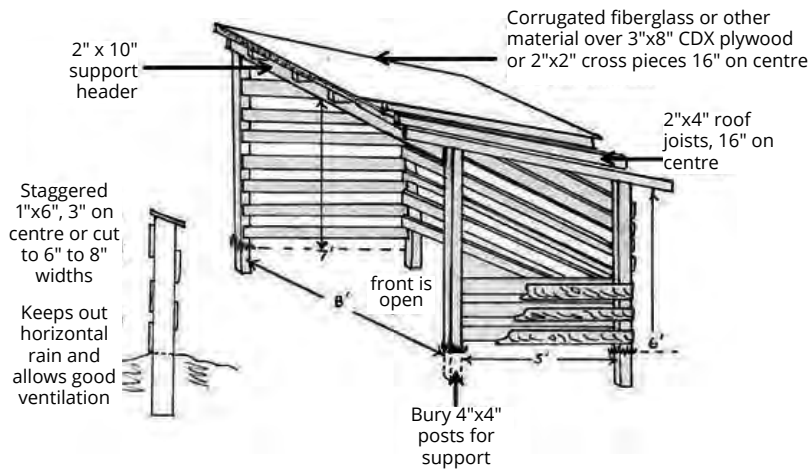
Never leave packed or unpacked product in the full sun after harvest. This sack of tomatoes was harvested in the morning; however, because the truck was not available, it was left in the full sun all day.

Simply covering produce with leaves, as shown below, is better than doing nothing. However, never use corrugated steel to cover produce, as this will increase the rate of heating.



Ideally, it is good to have a simple in-field storage area available, as sometimes prolonged in-field storage is unavoidable (i.e. the truck doesn't arrive, there are too few pickers, or adverse weather conditions occur). These events often require the harvested product is held longer on-field.

Below is a simple design for an in-field, short-term storage shed⁵.



Any shaded structure that is close to the field will do, as long as it doesn't create new risks. A simple lean-two or open-sided structure, as shown below, is fine. Do not use sheds or similar structures where chemicals and fertilisers are stored or mixed, as this will create a food safety risk.

(Below) A range of on-farm open sheds in Samoa.



'If produce needs to be held in the field after harvest for short periods, it must be placed in a cool, shaded area.'

⁵ Source of photograph and design - Pinterest 2016



SORTING AND GRADING

Sorting and grading are important steps to remove poor quality or damaged product prior to transport. While sorting and grading are required for exported produce, there are no accepted or 'standard grades' for domestically-sold fruits and vegetables in Samoa. The majority of sorting and grading by Samoan smallholder farmers occurs on-farm or after the crops have arrived at the market, normally based on colour, size and ripeness.

ON-FARM GRADING FOR BETTER RESULTS

It is preferable to have a dedicated area with a large bench or benches where product can be easily sorted and graded. A sorting bench should be located in a shaded area, with access to water for cleaning. Wire benches, that can be easily cleaned, are generally preferable to wooden benches.



Best to have benches at waist height to avoid excessive bending. More care and attention is taken during sorting if you are comfortable.

Sometimes sorting and grading has to occur in the field. For instance, it might be impractical to transport to the packing shed, or as is commonly the case, no such structure exists.

If sorting in the field:

- Use a shaded location if possible or create a 'Lean-To' structure.
- Consider using clean plastic sheeting for the ground.
- Position close to a clean water supply (if washing of produce is also required) or have large tubs of clean water.

Below is an example of a good approach to in-field sorting and cleaning by a smallholder papaya farmer in the Sigatoka Valley, Fiji.



A. Note – the simple box stool/chair. More care is taken when you are comfortable. B. Note – fruit being washed in a large tub of water. C. Note – clean plastic sheeting to place fruit.

Rather than sorting product on the ground, it is preferable to use a sorting table. While any table will do the job, aim for a lightweight design so it can be moved easily. A wire top will make it simpler to clean and will be less prone to heating if left in the sun. Clean cardboard is sometimes placed over the wire (but replaced daily) when sorting more perishable crops. It is important to ensure the table is a convenient height.



(A) An example of a good sorting table used by a commercial farmer near Apia, Samoa. (B) This sorting shed on southern Upolu, involving a simple, raised bench made using concrete blocks and timber planks.

Sorting benches must be located well away from chemicals and fertilizers. Ideally, there should be a dedicated area for sorting and grading NOT a general farm-use area (such as potting or seedling preparation, or general storage) as seen below.



Sorting tables should NOT be located close to where fertilisers, chemicals or potting mixture are stored.

IN-MARKET GRADING TECHNIQUES TO REDUCE LOSSES

In Samoa, most produce is graded and sorted in the market.

The short distances between farm and the market, comparatively low transport costs, and relatively large vendor market space make this possible.

In many incidences, in-market grading is preferable to on-farm grading given vendors tend to be aware of consumer expectations.

One down side of in-market grading can be the disposal of poor-quality produce. In practice this is not really an issue in Samoa, with most vendors only trading small quantities at a time. A significant portion of waste is returned to the farm to feed livestock.



In-market sorting is common in Pacific island municipal markets, and is often associated with re-packing product into smaller volumes for consumers.

In the Port Vila Municipal Markets, Vanuatu, vendors bundle or wrap produce into visually-attractive displays following grading (see below). This practice is less common in Samoa, where there is a greater reliance on biodegradable plastic packaging.



While size, colour and general produce uniformity are highly variable between growers in Samoa, it is important to aim for a level of uniformity within individual crates, particularly in fruit crops that will ripen after harvest. In fruits (including cucumber and tomato) it is important to grade consistently according to stage of ripeness. Packing produce of variable ripeness will result in further sorting on arrival at the market. Or if the product is not sorted, there is a risk that ripe or over-ripe fruit might rot and spoil adjacent produce. Over-ripe produce is also more likely to deteriorate in transport or storage.

It is important to sort and separate product based on the stage of ripeness.



This carton has tomatoes at a range of ripeness stages. Ripe fruit are more likely to damage in-transit. Green fruit are likely to be held in the markets before they can be sold. Aim to pack fruit with the same stage of ripeness in the one carton.



Uniform stage of ripeness - note the use to paper liner.



(Left) Tomato in the Fugalei Markets, Apia being sorted according to stage of ripeness.



(Right) Tomato graded and packed so all the product were of similar stage of ripeness.

WASHING

Washing produce to remove soil and surface contamination prior to packing is essential for some crops. When done correctly, this will improve product quality and food safety. However, poor washing practices can have the reverse effect and actually increase the risk of food contamination and postharvest diseases.

To begin the washing process, it is very important to make sure the water is clean and remains as clean as possible. To achieve this, try to have a constant flow of water, and an overflow to remove wastewater from the washing area.

Be careful not to cross-contaminate cleaned surfaces. Avoid putting washed produce back into the same field crate, i.e. where residual soil etc still exists. To avoid confusion, have different-coloured field crates, one for use in the field, and another to pack product after washing.



(Above) This in-field washing process has running water, produce held in crates and a washing area at a comfortable body height. However, the small water surface area will slow down the washing process, and there is no disposal systems for waste water. As such, the area will soon become muddy.



(Right) Too many people are using the washing space, there is no running water, and produce is being placed on the soil before washing.

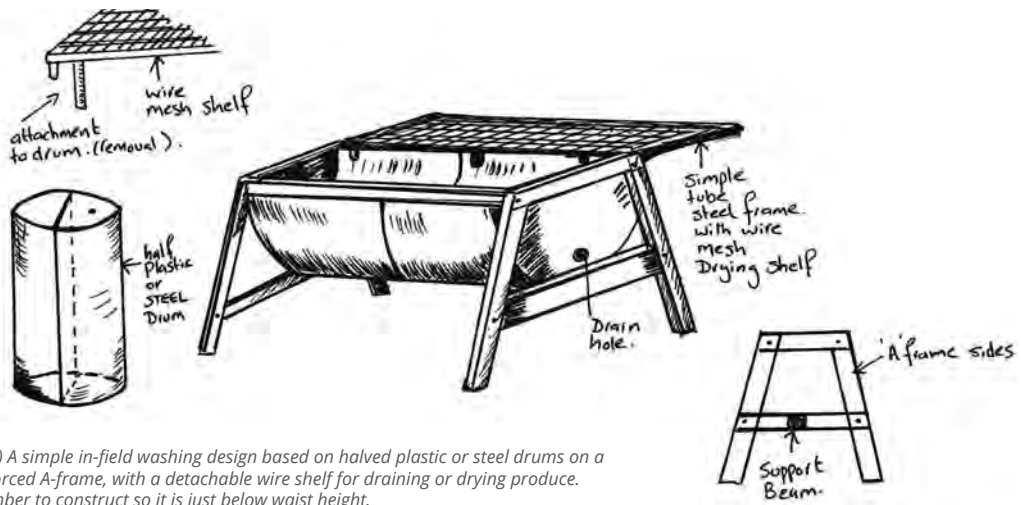


(Above) There is running water here; however, the tub on the ground will require a lot of bending. It is better to raise the tub to bench height.

Samoa's municipal water supply is normally fine to wash fruit and vegetables. The greatest risk is irregular water changing during or after use, resulting in a buildup of soil and potential food contaminants in the water.

There are some simple rules when it comes to washing fruits and vegetables.

1. Use large containers. Small containers need to be changed more frequently.
2. Aim to use a small volume of continuous-running water to help keep it clean.
3. It is preferable to spray produce with fresh water than emersion cleaning. However, avoid overly-high pressure which can easily damage produce.
4. Never place wet produce back in the same field container or on the ground as produce can quickly re-contaminate.
5. Aim to have a raised wire bench were washed product or crates can be temporarily placed prior to loading on the truck.
6. For fruit crops, dry produce before packing, as packing wet product into cartons can increase the risk of rots.



(Above) A simple in-field washing design based on halved plastic or steel drums on a re-enforced A-frame, with a detachable wire shelf for draining or drying produce. Remember to construct so it is just below waist height.

Some fruit crops, such as mango, will spurt or ooze sap or latex from the cut end once harvested. In some cultivars, this can cause severe skin reactions in people handling the fruit, or 'mango rash'. Some people are particularly sensitive to the mango sap.

If the mango variety you are harvesting is prone to this, it is advisable to use gloves and eye protection. Sap can also build up in the water if you are using non-flow-through water bath, and damage other fruit. A range of commercial detergents can be used at 1mL or 1g per litre during harvesting and washing to reduce the chance of injury. In Australia there is a range of commercially-available detergents for mango cleaning.

It is sometimes necessary to lightly brush or scrub fruit to remove soil and field material. When doing so, make sure that the brush is clean with moderately-firm bristles. Brushing too hard, or using a brush with very firm bristles can easily damage the fruit. Scrubbing brushes often harden with age; so it is better to use a new brush. Be especially careful when cleaning mango, breadfruit and citrus, as these crops are sensitive to skin damage.



A smallholder farmer near Leulumoega Tuai village cleaning pineapples with a household scrubbing brush.

After cleaning, make sure you have somewhere clean to place produce to dry. Don't put washed produce on the ground, on the grass or into the same container it was harvested.



If the product is washed in-market, aim to use two buckets of water.



(Above) A market vendor in the Port Vila Municipal Markets, Vanuatu washing locally-grown carrots. Note the use of two containers.

The most common mistake is to not change the wash-water frequently.

- Don't use water sourced from rivers, dams or creeks to wash produce.
- In fruit and vegetables where the skin is normally consumed, washing in dirty or contaminated water can be one of the major sources of food safety risk.



- Be careful not to inadvertently cross-contaminate wash water. It is important to make sure produce pickers don't wash their hands or harvesting tools in the same water used to clean the produce. Hands should be cleaned beforehand in separate water.
- Some larger-scale farmers in Samoa are using various hydroponic or nutrient-film product techniques, particularly for growing small quantities of lettuce and similar leafy vegetables. This production technique involves growing lettuce in a suspended solution of nutrients. This solution can splash onto the leaves during harvesting. It is desirable to use a two-stage washing process for leafy vegetable grown this way.

To highlight the importance and attention given to washing fruit and vegetables within the catering sector in Samoa, some enterprises in Apia wash all their vegetables using a purified water dispenser prior to serving to consumers.

'.....some enterprises in Apia wash all their vegetables using a purified water dispenser prior to serving to consumers.'

ICE-WASH BATHS: HYDROCOOLING

Hydrocooling involves the use of cooled water (1 to 4°C) to lower the temperature of harvested fruits and vegetables. When used in combination with refrigerated transport and storage, hydrocooling can extend product shelf life. This simple technology is very effective in reducing excessive field heat in some crops, or to help reduce product temperature prior to low-temperature storage.

Hydrocooling can be performed by emerging produce in iced water or by using commercially-available 'conventional coolers' that spray chilled water onto the produce. The most practical option for Samoan farmers is simple emersion. This involves a large tank/bath which is filled with water and enough ice to make the water cold. As with any postharvest practice involving water, it is important to ensure the water remains clean. One option to consider is a pre-wash to remove soil and associated contaminants before hydrocooling.

How effective cooling is depends on field heat (how hot the product is to begin), and the type of product (melons will obviously cool a lot more slowly than bok choy), and the volume of iced water relative to the product (small hydrocooling systems will heat up quickly).

Hydrocooling is not suitable for all crops. There are some that are likely to develop chilling injury when subjected to hydrocooling.

Crops suitable for hydrocooling:

- Leafy green vegetables (but not all)
- Cucumber (but not below 6°C)

Avoid hydrocooling:

- Various berry crops (such as wild raspberries)
- Tomatoes, eggplant
- Banana, mango, papaya, carambola
- Some herb species

The use of hydrocooling is still relatively rare in the South Pacific. However, due to its simplicity and an increasing trend toward direct selling to retailers using refrigerated storage, hydrocooling is anticipated to increase. At around \$3-5Tal per bag of ice in Samoa, the cost of using a simple hydrocooling system is also relatively low.

'As with any postharvest practice involving water, it is important to ensure the water remains clean.'

Below is further online reading aimed at smallholder famers:

A Low-Cost Hydrocooling Unit for Horticultural Commodities (University of Hawaii). <https://hilo.hawaii.edu/academics/cafnrm/research/documents/Alowcosthydro-coolerforvegetables.pdf>

Low-cost portable hydrocoolers (World Vegetable Centre). <http://avrdc.org/on-farm/postharvest/low-cost-hydro-cooler/>

PACKAGING



In the South Pacific, a wide variety of packaging is used to transport fruit and vegetables. In most cases, this is based on what is available and practical, rather than what is ideally suited to the specific crop.

In selecting a packaging option for a crop there are a few key issues:

- Consumer quality expectations
- Type of crops (perishable or semi-perishable)
- Mode of transport
- Price and availability
- Carton type
- Potential to recycle/ reuse

Ideally, packaging should be affordable, easy to access, and provide good protection to produce during transport. While there is little doubt that stackable plastic field crates offer good protection for most crops, in many incidences their use is not necessary. A simple indicator of the need to consider alternative options is the amount of in-transit damage observed in crops on arrival at the markets.

In Samoa, where the use of locally-made woven baskets is common, in-transit loss at the main municipal markets is often less than 5%. While this would imply little need for change, most restaurant, shops and hotels prefer to purchase produce in cardboard boxes or plastic crates. Ultimately, it is not all about reducing losses. Packaging type can influence food safety contamination risk. Packaging that can be re-used (i.e. plastic field crates and wooden boxes) must be cleaned prior to use, otherwise they increase food safety risk.

PACKAGING FOR PERISHABLE CROPS

(Opposite) Locally-made wooden stackable crates (10-15kg load capacity) are commonly used in Fiji for tomato and eggplant, but rarely used in Samoa. In Fiji, wooden crates are made from recycled timber, and are often lined with clean newspaper. When not overloaded, they lead to low in-transit losses.



(Opposite) Most commercial Samoan farmers use plastic field crates to transport tomatoes, leafy vegetables and citrus (limes). It is important to use crates that can be stacked easily. Note the retractable bars (red) on the crate. The main drawback of field crates is that they can be expensive, and extra effort is needed to ensure recycling/re-use.

(Opposite) Samoan farmers who sell leafy vegetables direct to restaurants and hotels often use polystyrene boxes. A frozen drink bottle is normally placed in the bottom of the container, which can be very effective in keeping the product cool during transport.



(Below) Shallow, over-filled plastic crates are often a higher risk option, but if used to pack leafy vegetables, which are carefully packed upright and then transported as single layer (i.e. not stacked) then this form of packaging can reduce damage risk. Consider pre-lining the crate with wet (clean) cloth or newspaper.



Packaging costs money. It is important to choose the right type of packaging and to use it in the right way.

PACKAGING FOR LESS-PERISHABLE CROPS

Heavy produce, such as taro, cassava, breadfruit, cabbage, head lettuce, watermelons and citrus, are often packed into 25kg sacks or into locally-made woven bags. This practice is common throughout the Pacific. While not ideal, for some crops that are transported over short distances using small trucks, this practice can be undertaken with limited losses during transport. In the case of cabbage and head lettuce, damaged portions are normally removed by vendors before display.

Problems arise when the produce is transported over long distances (such as the Savaii to Apia supply route) or by public transport (where product is commonly subjected to rough handling), or on overloaded trucks.

While there is a strong preference to use plastic field crates for such produce, the reality is that for many smallholder farmers, associated costs of purchasing plastic crates is not practical, or the supply-chain arrangement in place does not guarantee the return of the crates from the markets. Greater use of locally-made wooden cartons needs to be promoted in Samoa. In Fiji, such crates are almost the standard for commercial smallholder farmers.



(Above) Bulk product (such as taro) is also displayed and sold to consumers in woven baskets, also making it easier to transport from the market to home.

In general:

- It is better to use some form of packaging than no packaging.
- If you are transporting a small volume of produce, then woven baskets are unlikely to cause much in-transit damage. But avoid stacking baskets on top of each other if possible.
- Avoid using large sacks for produce, as these can be very heavy (sometimes >40kg), and are often dropped during unloading. If sacks are the only option available, use smaller sacks that can be easily lifted and loaded.
- Locally-made wooden crates of similar design to those used in Fiji for tomato and eggplant (see previous page) can be used for smaller produce, such as choko, citrus, eggplant and mango.
- Cardboard cartons (new or recycled) are a practical option if product can be protected from rain in-transit. Otherwise there is the risk the cardboard can rapidly deteriorate during transport.
- Stackable plastic field crates or boxes are the best option for truck transport.

An important issue is to match the packaging type to the risk factors associated with the transport route to market.

For example, watercress sourced from Apia and sold at the Fugalei Markets is traded in very small volumes, transported short distances (1-3km) normally by car or taxi, and sold quickly (within six hours). While it would be best to use plastic crates that drain easily, in this case, woven baskets are unlikely to be a problem. However, if the watercress was to be transported by bus or across a long distance, then there is a real risk of high postharvest losses.



Packaging selection also needs to account the human relationships within a supply chain. In those supply chains where the farmer has an ongoing commercial arrangement with the vendor, the retention and return of expensive plastic crates is less of an issue. However, in those involving middlemen or traders, it becomes a more complex. Some traders will provide plastic crates to smallholder farmers; however, the system breaks down when the crates are owned by the smallholder farmer. Elsewhere, plastic crates tend to be limited to farms that have a continuous trading relationship with a vendor or retail outlet, those selling directly to restaurant, hotels and shops, and those that involve in-market repackaging.

For high-risk transport situations (by public bus, local ferry)

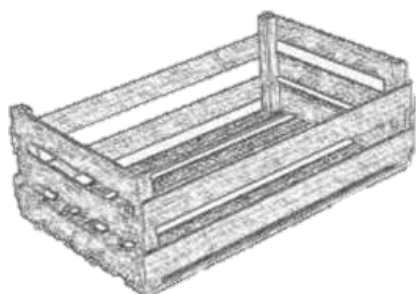
- Use locally-made wooden crates, plastic buckets or plastic stackable crates.

For medium-risk transport situations (product transported in small volumes, by closed truck and short transport distances such as Alesia to Apia supply route).

- Use recycled cardboard boxes, buckets, small sacks or woven baskets (which are unlikely to cause high losses). However, wooden or plastic stackable crates are the preferred option.

While most larger commercial farmers in Samoa will eventually adopt plastic field crates, for the majority of smallholder farmers, locally-constructed wooden cartons needed to be more widely promoted. This also creates a potential business venture opportunity. A few simple wooden carton designs are shown below. It is important cartons can be stacked without damaging the crop. This can be achieved by inserted wooden spacers in the corners.

However, if you construct your own wooden crates, make sure the timber does not contain harmful chemicals. Do not use wooden-pallet timber for this reason.





Avoid using plastic crates that cannot be stacked once filled.



One problem with plastic crates is storage after use and between harvesting seasons. This is particularly important given purchase cost and theft risk. Some Samoan farmers are using collapsible plastic crates to transport vegetables.



To be fit-for-purpose, packaging does not need to look pretty, it needs to be clean, stackable, and protect the crop.



Using a solid, plastic bucket with a lid, can protect produce during bus transport to market.

Wooden crates are widely used by smallholder farmers throughout Fiji, but are rarely seen in Samoa. Wooden crates are cheaper than plastic field crates, and offer better protection than traditional woven baskets.



Package size should also be considered. Any package that cannot be carried easily by one person, is likely to be dropped or poorly handled during loading and unloading. Sometimes, simply reducing the size to improve ease of handling, rather than changing packaging type, will make a big difference.



*If it takes five people to lift a sack, it's far too big (observed - Honiara Markets, Solomon Islands).
Packaging needs to be easy to handle and move, and must protect the produce.*

In some cases, it isn't wrong selection of the package that leads to in-transit damage, but picker, transporter and vendor unloading and storage practices.

Large sacks of taro or breadfruit should never be stacked in big piles as produce will eventually be damaged; rather, the sacks should be placed upright in single layers. Similarly, do not sit or lay down on sacks of taro. It is not uncommon for around one-third of taro to be damaged or bruised due to poor storage and handling practices.



Very few packaging types are able to withstand heavy weights.



Overfilling crates makes them difficult to stack, will lead to produce damage, and increases the risk of crates being dropped due to the crates being too heavy. Ideally, crates should not be loaded any higher than 5cm from the top of the crate.



Fill crates to below the handle inserts, so if needed they can be easily stacked.

'Overwrapping' woven baskets and field crates is not commonly seen in Samoa, however; this practice is widely used in the Solomon Islands, and parts of Vanuatu.

While this may help protect the crops during inter-island local boat transport, given the short transport distance in Samoa, it is best avoided. A major disadvantage of overwrapped cartons is that it increases the risk of heat retention in transport, especially if the product was afternoon harvested.



Overheating in cartons and sacks can be made significantly worse by storing them in the wrong location. In the photograph below, product is stored next to the Fugalei Market toilet block in full sun.

'A major disadvantage of overwrapped cartons, is that it increases the risk of heat retention in transport ... '



ON-FARM RIPENING AND STORAGE

Some crops, such as tomato, are often harvested hard-green or when a very slight orange colour ('breaker') and ripen on farm. Poor on-farm ripening is one of the most common causes of postharvest losses in tomatoes in Fiji.

How and where produce is ripened has an important effect on product quality, the level of postharvest losses and food safety.

Good ripening practices

1. Start with a uniform product. Sort fruit into different stages of ripeness (hard- green, slightly orange and ripe). This will make packing easier later on.
2. Remove any rotten or damaged fruit immediately. One remaining rotten fruit will soon infect nearby produce. Best to sort and remove rotten fruit daily.
3. NEVER ripen any fruit in the full sun. Some farmers and vendors try to ripen fruit in the sun to speed up the process, but this can significantly increase losses due to fruit rots.
4. Ripen product in a clean and protected location, making sure fruit is stored well away from stored chemicals.
5. Covering the crops in the evenings will offer some protection from pests.

Damaged, rotten or over-ripe produce needs to be removed daily during on-farm ripening. One rotten or damaged fruit can increase losses. Beware the residue left behind can also cause rots. Make sure the cloth is clean and dry.



On-farm ripening needs to occur in a location that reduces or removes pest risks. Most growers tend to cover the crop in the evening or undertake ripening near the house. A raised verandah or bench is a good location.

Normally farmers will ripen fruit in a safe and secure location near or inside the house, or on the verandah.



The photographs below are from Fiji (A) tomato being ripened on a house verandah (B) in special ripening area adjacent to a local house.



(C) In Samoa, fruit is often ripened at the municipal markets, or simply picked semi-ripened product and transported directly to market.

In the photograph opposite, note the green bananas stored in the sun and the ripened banana for sale. While it is good to have a dedicated area for ripened product, it must be clean, shaded (i.e. cool), protected from rain and out of the way of pests.

Chemical storage sheds should never be used to store or ripen fruit, due to a risk of food safety contamination.

Never store or ripen fruit in the same location that chemicals or fertilisers are or have been stored; as this will create a food safety risk.



While this Samoan farmer below has only harvested a very small quantity of tomatoes and is ripening the fruit in a small packing shed, fruit have been placed where they will be in the sun for a few hours each day. It is better to ripen fruit in constant shade. Better still, place fruit on a raised table to reduce the risk of contamination by pests and rodents.



Tomatoes being ripened by a Samoan smallholder farmer.

Ripening temperatures

While optimum-ripening temperatures can be influenced by cultivar type and growing condition, below is a general guide based on Australia grower recommendations.

Tomato

- The optimum ripening temperature for most cultivars is around 20-22°C .
- At temperatures below 18°C ripening will be slowed.
- At temperatures above 22°C there is a risk that the fruit will develop poor or uneven colour.

Banana

- The optimum ripening temperature is 14 to 18°C.
- There is a progressive loss of fruit firmness above 18°C.
- Ripening fruit above 25°C will adversely reduce colour and taste.

Mango

- The optimum ripening temperature for most mango cultivars is 18 to 22°C.
- If ripened above 22°C, there is an increased risk of rots, and retention of green skin colour.
- Ripening below 18°C will reduce colour and flavour, and increase the risk of rots.

TRANSPORT



TRANSPORT PRACTICES AND REDUCING LOSSES

Most horticultural produce in Samoa is transported relatively short distances, normally less than 20km. It is therefore not surprising that associated in-transit losses are usually low (less than 5%). However, things can and still go wrong. The likelihood of in-transit damage is based on the type of packaging used (or often a lack of any packaging), where and how consignment is arranged on the truck, and care and attention taken loading and unloading.

Most fruits and vegetables in Samoa are transported in uncovered small trucks. Produce transported this way can rapidly heat up in-transit, especially leafy vegetables. There is also the risk of exposure to rain, which can increase the incidence of postharvest rots. It is always best to cover your load.

A significant portion of crop is also transported in the absence of packaging. Loosely-filled trucks transporting taro, and highly-perishable crops, such as leafy vegetables, are often seen at the Fugalei Markets in Apia. Loose packaging is not only more time consuming and labour intensive during unloading, there is a greater risk of damage to the crop. It is better to avoid transporting unpackaged produce.



(A) Loose-filled (unpackaged) taro consignment in Samoa. (B) Loose-filled (unpackaged) pineapple arriving at the Suva Markets Fiji.
(C) Commercial vegetable farmer in Samoa loose packing leafy vegetables.
(D) Unprotected banana being transported for processing in Samoa.

Loose-filled consignments should always be avoided. Even root crops, such as taro, are more likely to develop internal bruising if transported in this manner. The transport of unpackaged product is sometimes justified, such as bulk transport of product for processing. But remember:

Loose filled consignments = higher postharvest losses.

TRANSPORTING BY OPEN TRUCK

If an open truck is the only option to transport your produce, there are a few simple steps to reduce the chance of incurring increased postharvest losses.

- 1. Park the vehicle in shade while produce is being harvested.** Most truck trays are made of steel and will heat up very quickly if left in the full sun. This heat can quickly radiate through the bottom layer of cartons and damage produce.



- 2. Make sure the truck tray is clean.** Farm trucks are used to carry a wide range of things, including fertilizers, chemicals and livestock. It is very important that the truck tray back is cleaned before use.

- 3. Some farmers will line the bottom of the truck with large leaves.** This practice is common in many Pacific islands, especially where cartons are not available. This will help protect crops from excessive radiated heating. There is also the potential added benefit of providing a semi-clean surface to place cartons and crops.



- 4. Make a lightweight steel frame to support a nylon or plastic tarp.** Better to have a design that can be quickly installed or removed. Side curtains that can be easily rolled down if required will provide added protection.



- 5. Make sure the truck tray is in good condition.** Produce will easily damage if there are sharp edges and a damaged surface. Damaged tray-backs are also more difficult to clean. Consider using wooden sheeting on the bottom of the tray.



If possible, consider making a simple and removable steel frame over the back of the truck. Below are two examples of trucks in Samoa where a locally-made frame has been installed.



Photograph above: This is good truck setup. The tray back has a canvas covering, with roll-up sides, so produce is protected during transport and to make unloading easier.



ROADSIDE PICKUP

If you are using a trader or middlemen to transport your product to market, some farmers place the crop on the side of the road ready for pick up. This practice is very common in Fiji. In Samoa, many smallholder farmers rely on public buses to transport produce. Always cover the crop to protect it from the sun or place in a shaded location.

Don't forget, placing product on cement, concrete flooring or the roadside, which have been exposed to the sun, is likely to be very hot and will stay warm even if in the shade. Place some cardboard or timber underneath the cartons to provide added insulation from radiating road heat. Don't forget: **Always cover the crop.**



These cartons of papaya and taro in Fiji, awaiting truck pickup, are in the full sun and also on the hot cement.

Roadside storage can also increase the risk of food contamination. This bok choy on the side of the road in the Sigatoka Valley in Fiji is covered by dust from passing trucks and buses.



Vegetables should not be stored on the side of the road. If unavoidable, make sure they are well covered to protect against dust from passing traffic.

CONSIGNMENT LOADING

Overloaded trucks are a common sight in Fiji (see below), particularly during peak season. This is due to a limited number of trucks, longer transport times than Samoa and higher production volumes in places such as the Sigatoka Valley.

These tightly-packed and overloaded trucks create much less in-transit impact damage than would be anticipated. The excessive weight and volume of the product transported translates to much lower transport speed.



In Samoa, due to the smaller scale of production and closer proximity of many horticultural production centres to the Central Markets, overloaded large trucks are rarely seen. In fact, there is greater risk of damage associated with low volume-poor- configured loads, where product can move around in transit.

- Given the smaller scale of production across much of Samoa (compared to Fiji), consignment loads are usually much smaller and involve frequent deliveries. In the Central Markets in Apia, it is not uncommon for product to arrive throughout the day.



- Overloading generally occurs in Samoa when farmers use small utility vehicles to transport loose- filled heavy produce, such as taro, coconuts and banana.



- When transporting product by public bus, there is a much greater risk of damage to the crop during the unloading process than during the transport route to market.



- Road works and the unsealed roads adjacent to most farmers tend to be the highest-risk areas during transport to markets.



When product is being delivered to a series of markets or retail outlets, the risk of the crates moving and impact damage occurring, progressively increases as load weight decreases.



- (A) The consignment from a commercial Samoan farmer on leaving the farm.
 (B) The same consignment following a series of deliveries to retail outlets.

In most horticultural transport systems observed in Samoa there are **some good practices**, and a few things that **could be done better**.



Vehicle is not overloaded and cartons are stacked in a manner that is likely to be stable in transit.

Produce is stacked towards the front of the tray, where the risk of produce bouncing is much less.

The use of field crates to transport the product will mean quicker unloading and less damage.

The use of the same type and size of field crates means loading and stacking are easier and more stable.



There is no cover over the load meaning the produce has been transported in the full sun.

Field crates are over-filled. This will cause some damage if produce is stacked in the market, or will necessitate some repacking.



It would have been better to use of a cover over the consignment, and to pack less produce into individual cartons.

TRANSPORT PRACTICES FOR FOOD SAFETY

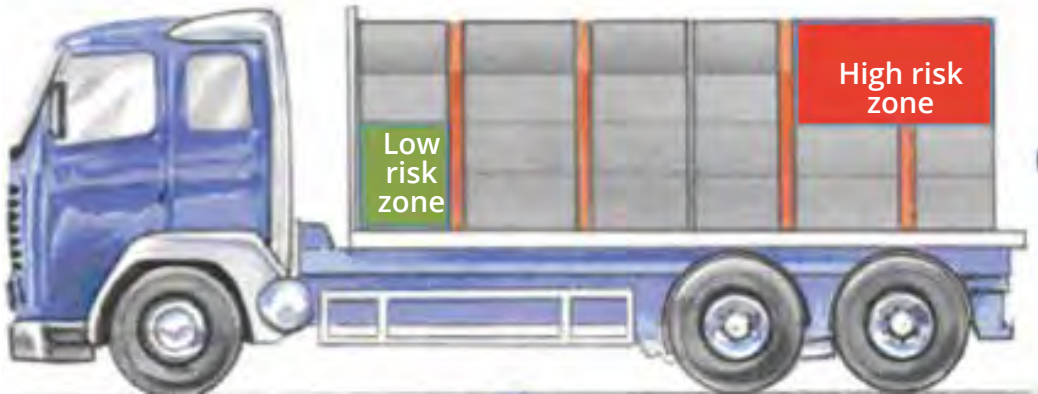
Remember, all fruit and vegetables are food. As such never transport them with chemicals, spray packs or any material (i.e. oils, petrol, manures) that can contaminate product in transport. Transporting fruit and vegetables with packaging that has been in contact with these items, i.e. empty spray packs, should also be avoided.



REDUCING THE RISK OF IN-TRANSIT DAMAGE

There are four major contributors to product damage during transport.

1. Vehicle speed
2. Condition of the road
3. Where the product is placed in the truck
4. Package type



If transporting product that is likely to easily damage during transport, it is best to do the following.

- Place produce at the front of the consignment (shown above in green),
- Drive more slowly.
- If possible, avoid dirt roads.
- Use stackable crates.
- Don't stack crates too high (preferably three or less field crates per stack).

Based on research to document in-transport conditions in Samoa, and elsewhere in the Pacific, there is a **series of key findings**.

- Produce transported by car or utility vehicle are more vulnerable to impact damage than produce transported by truck. Drivers tend to travel much faster in these vehicles, especially if transporting small volumes of product.
- Poorly maintained vehicles, especially those with worn shock absorbers, are often the worst vehicle option.
- Very poor roads can sometime create less damage, simply because drivers tend to take more care when the road conditions are poor.
- Truck drivers familiar with local road conditions are often more likely to drive faster than if the road conditions are less familiar.





How a fruit and vegetable consignment is packed, loaded and transported is often the result of a series of inter-related factors. The photograph above is of a commercial mixed-produce consignment from the Alesia region. In this example, the farmer used several different types of non-stackable plastic crates. The load is configured as a single layer with the more perishable, Bok choy, loose packed.

The placement of produce, i.e. Bok choy towards the front of the consignment and the comparatively robust root crops at the rear (where the risk of in-transit impact damage is higher), simply reflects the farmer's order of harvest.

Single-layer loading is highly inefficient in terms of utilisation of space, and loose transport of leafy vegetables is not ideal. However, when this consignment was assessed on arrival, there was very little in-transit damage. A combination of a relatively stable load and short transport distance (less than 15 km) negated much of the underlying postharvest risk.

Important points:

- Transport decisions (i.e. the type of carton used), can cause flow-on effects;
- Good postharvest transport practice (such as placing more perishable crops towards the front of the consignment) can be the result of simple practicality;
- The relevance of load design and configuration, while always important, are often proportional to transport distance and time.

COMMON PROBLEMS WITH HORTICULTURE TRANSPORT

AND HOW TO FIX THEM!

Non-stackable or incompatible packaging

In the picture below, a Samoan farmer was transporting produce less than 15km in a purpose-used closed truck but experienced considerable in-transit loss due to the load moving. This problem occurred due to the use of a range of different field crates and packing bins that could not be stacked well.



Solutions

- Purchase a standard set of field crates, and make sure they can be stacked easily. Some examples of stackable field crates are shown below.



- Use a series of internal-load brackets. These are wooden panels that are placed within the load, creating some protection against in-transit movement.
- Position a series of horizontal shelves within the truck. These must be fastened in place to create an area to place crops vulnerable to damage. A lip or edge is needed to secure the load.

Loose on-farm loading of crops

While loose loading of leafy vegetable crops will increase the amount of damage during transport and unloading, it may also significantly increase the risk of food safety contamination, especially on farms where organic manures are used.

Even if product is washed after harvest, the manual loading of crop onto a truck can create significant cross contamination. Mud (and possible manures) can be transferred to the truck tray during the loading process on picker's boots and shoes (see below).



Solutions

- It is best to place washed produce into plastic or wooden crates which are placed directly into the truck. Be careful not to first place crates on the ground, as soil can be transferred to the truck.
- When loose packing is unavoidable:
 - » Have a dedicated loader remain with the crop until fully loaded.
 - » Use a roll of clean plastic or tarp sheeting that is progressively unrolled as the truck is filled. Or, have clean cardboard that is progressively added as a protective covering over the floor.
 - » Use a truck or tray back that can be loaded from the sides, thus removing the need to walk on the tray back.

Inefficient loading and unloading practices due to the wrong packaging

The primary objective of any good postharvest handling system is to handle produce as little as possible. For leafy vegetables, which are prone to damage, this is especially important. The most common cause of excessive or inefficient handling is selecting the wrong or incompatible packaging.

(Below) The combination of a large wooden field crate that could not be easily unloaded and too few field crates, meant this Samoan farmer had to repack twice on farm and a repack on arrival. This farmer has much higher postharvest losses (all due to packaging and loading practices) compared to other similar-scale farmers.

Every time produce needs to be repacked or re-sorted damage risk increases and so do labour costs.



Solution:

- Use smaller 25-30kg field crates that can be easily handled by one person. This reduces the need to unpack and repack (saving time, and labour), and reduces the risk of damage during handling.
- Purchase a standard set of field crates, making sure they can be easily stacked.
- Consider using a truck with drop-down sides, which when combined with field crates, can be loaded and unloaded quickly and with little risk of product damage.



STORAGE



STORAGE HINTS TO MAINTAIN FRESHNESS

Much of the horticultural supply chains in Samoa are based on harvesting, transporting and selling the product as quickly as possible. With the exception of imported fruit and vegetables, and farmers selling directly to major retail outlets, resorts, hotels, or restaurants, the vast majority of horticultural produce is transported and stored under ambient (room) temperatures. In Samoa, mean-daily temperatures are between 22°C and 30°C,

To assist those commercial enterprises using cool storage, a list of optimum storage temperatures for most of the fruit, vegetable and root crops commonly grown in Samoa is been provided in this guide (see table on page 69).

However, it is important to note that recommended storage temperature can vary depending on the cultivar type, whether the fruit has not-yet ripened (i.e. hard-green), whether produce is sourced from an early- or late-season harvest, and whether any pre-heating has been applied (for example, when produce has been subjected to a heat treatment as part of a disinfestation or postharvest disease control protocol).

While not listed, the humidity in storage is also an important consideration. Low humidity storage increases the rate of water loss for some crops; and high humidity increases the risk of diseases in other crops.

There are three distinct situations where horticultural produce may be subjected to prolonged cool storage in Samoa.

- Commercial cold rooms used by local retail outlets (A)
- Small food storage cabinets and cool storage rooms used by restaurants (B)
- And, commercial export and import sea-freight containers (C)



In mixed-produce storage situations, such as retail and restaurant outlets, the temperature and humidity in cold rooms is often set at a constant standard (normally 10 to 12°C). In most retail outlets that we visited in Samoa, cool rooms were used to store a wide range of perishable produce, regardless of the sensitivity of the produce to low temperatures.

While cool storage is the best way to extend storage life, it is important to remember that for some produce, temperatures that are too cool can elevate postharvest loss. Most tropical fruits for example, including mango and banana, can be highly sensitive to storage below 13°C. Similarly, fruits that will continue to ripen after harvest, such as tomatoes, can also be adversely affected by low temperature storage. In this instance, the critical period to avoid is the on-set of ripening. Often once fruit have fully ripened, it becomes less sensitive to lower temperature storage.

Chilling injury normally does not appear until shortly after produce has been removed from low temperatures. It can involve internal discolouration (pineapple), loss of taste (tomato), uneven colour development (mango), surface pitting and lesions (citrus), or a general greyish colouration (banana), or a combination of the above.

Humidity in cool rooms in Samoa can be highly variable and is rarely checked. This can be especially problematic in commercial display cabinets used by restaurants in Samoa. Given the uncertainty of humidity, it is important to consider the type and nature of packaging used during storage. Storing loosely-stacked leafy vegetables (see photograph below) in the absence of some form of packaging, will result in premature wilting and reduced storage life and lowered product quality.



There are a few good online guides on optimizing cool room humidity and temperature.

- http://cotes.com/wp-content/uploads/2014/10/Cotes_ColdstoreBooklet.pdf
- <http://www.fao.org/WAIRdocs/x5403e/x5403e08.htm>
- http://www.airah.org.au/imis15_prod/Content_Files/UsefulDocuments/07-13-Cool-rooms-owners-operators.pdf

Some Samoan smallholder farmers who sell leafy vegetables direct to restaurants, have recommended produce be stored in sealed plastic containers. Such packaging can provide good protection against the adverse affects of low-humidity cool storage. While it is always a good idea to have any commercial cool rooms regularly checked for temperature and humidity, if this is not practical, then product condition can be a good indication. Rapid wilting of lettuce and bok choy is a good sign the humidity is too low.



COOL-STORAGE HYGIENE

Hygiene within cold rooms is critical. Dirty cold rooms can result in increased postharvest loss due to rots and can also create food safety contamination.

- Cold rooms should be cleaned regularly using a commercial disinfectant.
- Never store dirty crates in a cold room (see photograph below).
- Be careful when moving produce in and out of a cold room, in terms of dirty boots and shoes.
- Never store produce on or near the floor.
- Always pack into some form of box or carton.



Storage temperatures for fruit and vegetables grown in Samoa

Product	Samoa Name	Optimum storage temperature (°C)	Comments
Avocado (hard)	Avoka matua	4 to 5 6 to 8	Cultivar-Hass Other cultivars
Avocado (ripe)	Avoka pula	7 to 10	Ripen avocados at 15 to 20°C
Banana	Fa'i	13 to 14	The optimum temperature to ripen banana is 14 to 18°C. Bananas are sensitive to low temperature avoid storage at 13°C or less.
Bean	Pi	4 to 9	Variable depending on cultivar type.
Breadfruit	Ulu	13 to 15	Chilling injuries have been reported after one week at 12°C.
Capsicum	Pepa	7 to 13	
Carambola	Vineka	5 to 10	Optimum storage temperature varies with cultivar type.
Cassava	Manioka	2 to 5	3°C is reported as optimum by some authors.
Chinese cabbage	Kapisi saina	0 to 4	Some cultivars can be stored at 0 to 2°C.
Cucumber	Kukama	10 to 13	Will start to show chilling injury after two to three days if held below 10°C.
Custard apple	Sasalapa palagi	15	Chilling injury is likely at 10°C.
Eggplant	Isalaelu	12	Eggplant have been reported to chill if stored below 10°C.
Guava	Kuava	5 to 10	8 to 10°C for green or partially ripe fruit; 5 to 8°C for ripe fruit.
Jackfruit	Ulu Initia	12 to 14	Limited literature, best to aim for 14°C.
Lemon	Tipolo samasama	10 to 12	Green fruit should be stored at 12°C and yellow fruit at 10°C. Some cultivars will chill at 10°C or below.
Lettuce	Kapisi fai salati	0 to 1	
Lime	Tipolo meamata	8 to 13	Temperature will depend on the cultivar grown.
Mango (green)	Mago matua	13	
Mango (ripe)	Mago pula	18-22	At higher temperature, fruit may not develop good colour.
Melon	Meleni	5 to 10	For honey dew melons store at 5 to 7°C.
Okra	Oka	10 to 12	Some authors recommend 7 to 10°C.
Pak Choi (bok choy)	Kapisi saina paepae	1 to 5	Humidity during storage is important.
Papaya	Esi	7 to 13	At 7 to 10°C there is a risk of some chilling injury occurring depending on length of storage. Fully-ripe fruit can be held at 1 to 3°C for five days.
Passionfruit	Pasio	7 to 10	Yellow-skinned and purple-skinned cultivars likely to have slightly different optimal temperature requirements.
Pineapples	Fala	12 to 15	For one week, storage product can be stored at a lower temperature. Browning is a sign of chilling injury.
Plantain	Fa'i palagi meamata	12 to 14	At 12°C mature green plantains should be stored for three to four weeks.
Pummelo	Moli ai lapoa (piniki aano)	9 to 12	Some authors report optimum storage at 12°C, there are numerous cultivar types.
Pumpkin	Maukeni	10 to 13	
Rambutan	Lamaputana	7 to 12	Optimum temperature will vary depending on skin colour type (i.e. yellow or red).
Soursop	Sasalapa	13 to 15	Fruit will develop chilling injury below 12°C.
Tomato	Tamato	12 (green) 5 (ripe)	Aim to store tomatoes at 20 to 22°C during ripening.
Taro	Talo	7 to 13	Some authors recommend 7 to 10°C.
Watercress	Kapisi vai	0 to 1	Low humidity will reduce storage life.
Watermelon	Meleni	5	Some authors recommend 7 to 10°C.



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CLOSING COMMENTS

Remember, to reduce postharvest losses and improve produce quality you must take into account your resources and circumstances. If you invest money or effort to improve postharvest handling practices and do not achieve better prices, less waste or safer food for the consumer, then your time and money are wasted.

Forget about aiming to impress, the focus is on being practical. It is not about making the handling system look pretty. Rather, it is about making the handling system more efficient and profitable for farmers AND safer for consumers.

In the majority of cases, a lack of technology is not the cause of postharvest losses; often someone has simply made a mistake or has not practiced enough care.

And ultimately, the key message is to strive to do your best. There is nothing wrong with applying third-best practice if that is the best you can afford. Sometimes, postharvest practices and technologies developed and used in Samoa are better than imported solutions.

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