



FIJI DALO QUALITY MANUAL



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Preparation of this manual builds on previous publications on dalo production and the technical information and knowledge of many people. In particular, the contribution and photos from Professor Steven Underhill (University of the Sunshine Coast, Australia), content of *Better postharvest handling for Samoan smallholder farmers: A practical guide* (Underhill, S; 2017); and inputs from Biosecurity Authority of Fiji, SPC Land Resources Division and dalo exporters in Fiji.



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Foreword

Dalo (*Colocasia esculenta*) is an important staple food for Fijians and most Pacific Islanders. It is commonly grown throughout Fiji and has cultural significance to the I-Taukei community. During Fijian traditional ceremonies, dalo is usually presented as '*magiti*' or special ceremonial food.

Dalo plays an important role in the agriculture sector's contribution to Fiji's economy as the largest agriculture export commodity after sugar. Since 2015, the volume of dalo exported continued to increase at annual average rate of 0.2%. In 2017, total dalo export earning was around FJ\$22m whereby 42% were from the New Zealand market.

The Fiji Dalo Quality Manual provides a one stop shop of technical information for farmers. It highlights best practices of growing the finest product with quality that is maintained along the value chain, for both domestic and export markets.

The manual will allow Ministry of Agriculture stakeholders to better equip themselves with information and advice needed to advance in the dalo industry at domestic, regional and international levels.

It provide guidelines and opportunities that elevates our reputation as quality dalo producers and suppliers.

The manual clearly suggests that nothing can be achieved in isolation. It will take concerted effort and teamwork by all stakeholders to ensure its successful implementation.

I acknowledge and commend the Dalo Team - officers from the Ministry of Agriculture, Biosecurity Authority of Fiji, SPC, donor partners and most importantly Farmers and Exporters - for all the work that enables the production of this manual. I urge us all to continue to communicate and work together to ensure that we achieve all that is outlined in this booklet.

God bless the dalo industry and Fiji!



Hon. Inia B Seruiratu

Minister of Agriculture, Rural & Maritime Development, National Disaster Management and Meteorological Services

Introduction



Dalo (*Colocasia esculenta*)

Dalo (*Colocasia esculenta*) is one of the oldest cultivated crops in the Pacific, and it is believed to have been transported across the Pacific by the early Polynesian explorers from South East Asia. As a traditional staple food in Fiji it has significant importance in everyday meals as well as part of traditional obligations and ceremonies. Dalo holds an important place in the life and diets of Fijians and communities from other Pacific Island nations. Quality is important and this needs to be kept in mind by farmers and all those involved in bringing dalo to markets.

Fijians and other Pacific Island communities living overseas also value good quality dalo, and it is important that Fijian dalo is recognised as a quality product to ensure it continues to be sought after and achieves good prices in these export markets. Dalo is also an international crop, grown and consumed around the world. There are approximately 82 varieties of dalo recognised in Fiji, and about 12 of these varieties are commonly cultivated by farmers. The different varieties vary in their taste, colour and texture, but also in their keeping qualities and agronomic characteristics.

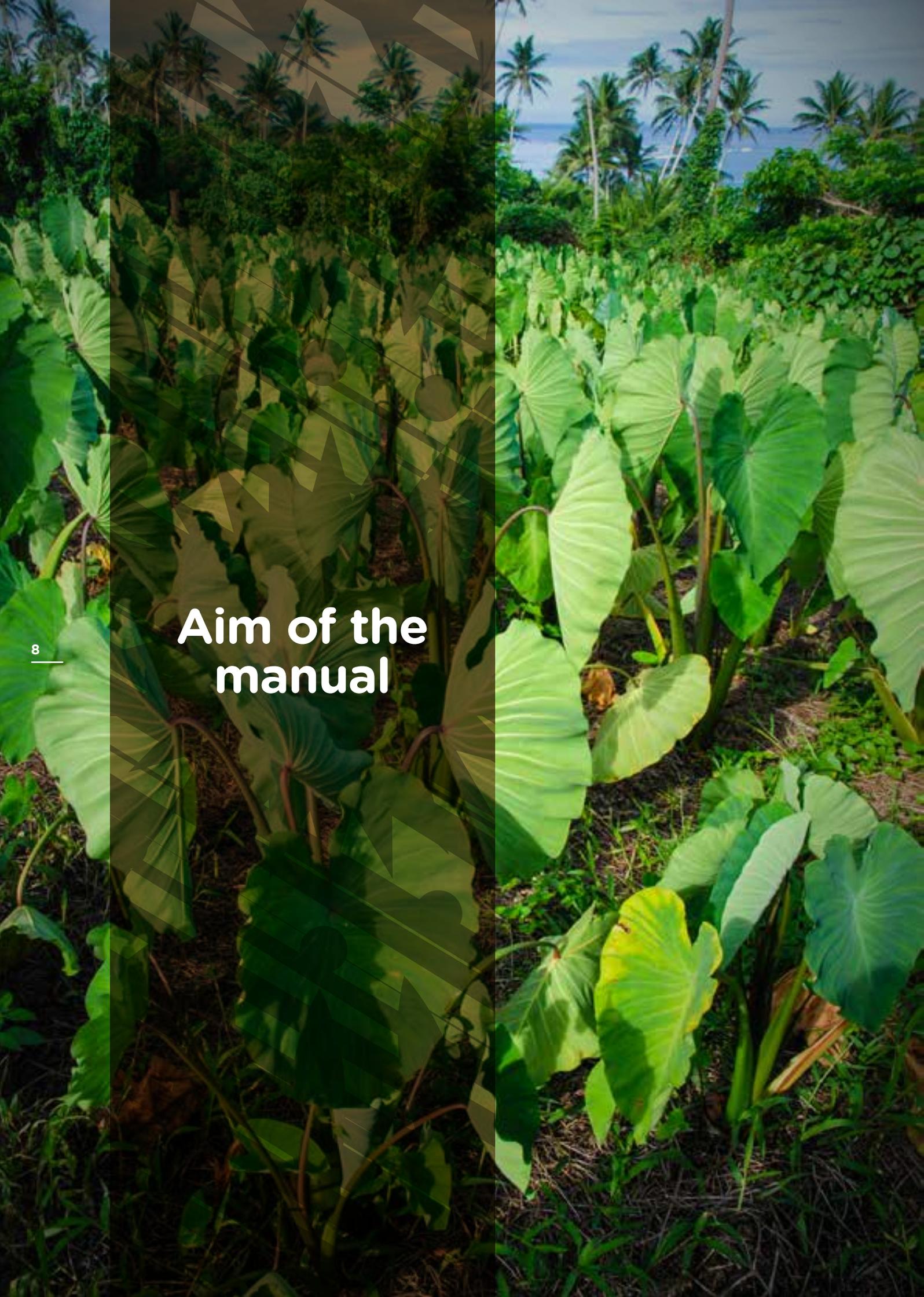
Until the mid-1990s, dalo trade in the Pacific was dominated by Samoan farmers producing dalo for Pacific Islander communities in New Zealand, Australia, and the United States. An outbreak of Taro Leaf Blight in Samoa in 1993 devastated dalo production in Samoa. Fiji started to grow the pink “Samoan” cultivar that was particularly sought after by the Samoan communities in these countries to fill the demand created by the decline in Samoan dalo production. In recent years production from Samoa has recovered and there is more competition in dalo export markets.

The corm, stalk and leaves of dalo are edible. The dalo corm has been found to be a good source of carbohydrate, fibre, minerals especially potassium and vitamins (especially B-complex)¹. Dalo is also reported to have a relatively low glycemic index² compared to a range of staple foods. However, dalo has irritating, needle-like crystals (calcium oxalate) that can cause itchiness and irritation. Dalo needs to be cooked to allow these crystals to break down. Dalo can be prepared in many ways, including; baked, steamed, boiled, fried, processed into flour for baked goods and it has even been used to make beer. There are also opportunities to develop new products based on the characteristics and nutritional benefits of dalo.



1 <http://www.glycemicindex.com/foodSearch.php?num=2008&ak=detail>

2 Darkwa S, Darkwa AA (2013) DALO “*Colocasia esculenta*”: It’s Utilization in Food Products in Ghana. *J Food Process Technol* 4: 225 <http://dx.doi.org/10.4172/2157-7110.1000225>



Aim of the manual

This manual has been developed to help dalo farmers, middlemen and exporters in Fiji provide customers with the best quality dalo. The information in this manual can assist in improving the quality and consistency of dalo being produced and traded both for local and export markets, and hence help to improve financial returns from the sale of dalo. The manual focuses on the dalo corm, which is often used fresh, but may be processed into a variety of products. The quality of these processed products depends on starting with good quality dalo. The production of dalo leaves for sale as fresh leaves in local and export markets is briefly described in Appendix 1.



The aim of this manual is to ensure that dalo grown in Fiji is:

- **Produced, harvested and processed according to good handling standards to maintain its quality;**
- **Safe and healthy to consume;**
- **Locally and internationally renowned and recognised as a quality product; and**
- **Complies with the biosecurity, quality and other requirements of target export markets.**

Adopting good farming practises and good handling practises after harvest has a range of benefits, including reducing the amount of dalo rejected due to spoilage. Adopting good practises will also help to ensure that Fijian dalo is supplied into local and export markets in good condition so that it maintains its nutritional and taste qualities, has a good shelf life and is attractive to customers.

It is important to note that there may be government regulations and requirements by export markets that will change from time to time, and it is important for farmers to check with the Ministry of Agriculture, Biosecurity Authority of Fiji, middlemen and exporters to understand how requirements and demands may be changing.

It is also important to note that advice from the Ministry of Agriculture about varieties, specific pest and disease control issues and measures and fertiliser application is also likely to change over time. Farmers should regularly talk with Ministry of Agriculture staff to get the latest updates and advice.

There is increasing competition in dalo export markets from other countries in the Pacific and beyond. New Zealand and Australia also have very stringent import conditions which mean they will only accept dalo that is of high quality and has been processed appropriately. For these reasons it is increasingly important that there is a focus on delivering high quality dalo by all those involved in dalo production and export.



What is dalo quality?



This manual is mainly concerned about producing quality dalo corms for export, but this is not the only way of looking at dalo quality.

Quality is a subjective term, and different people vary in their views and these views can vary depending on what aspect of dalo is being discussed. For example, ideas about dalo quality can vary depending on whether the person is growing the dalo, if they are buying it from local markets, if they are exporting it, if they are cooking it or if they are consuming it. A customer buying dalo in the local market could have a very different view of dalo quality compared to an exporter preparing quality dalo for export.

For people consuming dalo their first thought on purchasing dalo to cook may be about its appearance and freshness, along with a range of attributes such as colour, taste and texture. Pacific Islanders buying dalo in markets in Australia, New Zealand or the United States of America might look to buy varieties that are similar in their taste and texture to the varieties grown in their home countries. For example, Fijians living in Australia or New Zealand might prefer to purchase Uro ni Vonu over Tausala ni Samoa.

At a local market customers will be looking for mature dalo (which is beginning to taper at the top as the leaves senesce or die back) with an even shape (either round or oval depending on the variety) without signs of possible bruising from transport, damage from dalo beetle or similar and without any visible rots. It is also likely that these customers will prefer dalo which has had some of the surface roots and skin removed so that they can more easily check the quality of the dalo.

Exporters purchasing dalo for markets outside of Fiji can have strict requirements for quality. Fresh dalo for sale in markets overseas may be displayed next to dalo imported from Tonga, Samoa and other countries. For the dalo to enter these markets it must first meet the stringent biosecurity requirements of the importing countries, and imported dalo may also be tested for pesticide and heavy metal residues. Exporters judge quality on the basis of the dalo being healthy and free from damage, that it meets their size requirements and that it has an even shape that can be cleaned easily. Exporters need to make sure that all the dalo they send can reach these markets in good condition. Poor quality dalo can cause difficulties meeting biosecurity requirements and jeopardise their relationships with overseas buyers.

Poor quality dalo will result in disappointed customers and also to wasted dalo that cannot be sold and is thrown away. In export markets it can lead to a poor reputation and once markets are lost to other suppliers it can be difficult and very costly to get these markets back. Farmers, middlemen and exporters all need to work on this to ensure that Fijian dalo is of a consistently high standard. The continued good reputation of Fijian dalo in international markets depends on this.

This manual looks at how dalo is produced and handled, and explains how different practises influence dalo quality.



Quality assurance

Consistent quality can be very important for exporters who are trying to maintain export markets and competing with product from other exporters and other countries.

Formal quality assurance standards can be implemented by large exporters where the market has justified the cost, or the exporter has an interest in developing good practise in line with their business aspirations. Formal standards, such as HACCP, may be a requirement for some markets.

The acronym HACCP refers to Hazard Analysis and Critical Control Points. This standard focusses on implementing a systematic approach to ensure food is safe and that steps are put in place to ensure that the risks from biological, chemical, and physical hazards are reduced to safe levels. The good agricultural practises and good harvesting and handling practises identified in this manual can help in the development of a HACCP system.

There are 7 principles generally associated with implementing a HACCP quality assurance system. These are:

Conduct a hazard analysis

Identify the steps involved in producing the fruit or vegetable on the farm, through to preparing it for market and export. At each of these steps food safety hazards are identified and measures put in place to control the hazard. A food safety hazard can be any biological, chemical, or physical property that may make the food be unsafe for human consumption.

Identify critical control points

Points or steps in the food production and manufacture process are then identified where the food safety hazards can be prevented, eliminated, or reduced to an acceptable level. These are the critical control points.

Establish critical limits for each critical control point

Critical limits are the maximum or minimum values to which a physical, biological, or chemical hazard must be controlled to prevent, eliminate, or reduce that hazard to an acceptable level. Critical limits are identified for each of the hazards at the various control points.

Establish critical control point monitoring requirements

The hazards at each of the critical control points are then monitored. It is important that the frequency of monitoring, who is doing the monitoring, and how the measurements are taken are clearly described.

Establish corrective actions

Corrective actions need to be identified which can prevent potentially hazardous food from entering the food chain. These actions need to be implemented when critical limits are identified during monitoring. Part of the actions include identifying why the problem occurred and taking steps to prevent it from happening again.

Establish procedures for ensuring the HACCP system is working as intended

Once a system for monitoring and addressing hazards has been established it is important that the system is checked to make sure that it is working properly and that it is picking up hazards when they occur.

Establish record keeping procedures

It is important that appropriate records are kept to prove that the food was produced safely, but also to document the HACCP system and show that it is being implemented.



**Dalo market
and supply
chains in Fiji**

Dalo markets

The Fijian Ministry of Agriculture has estimated that around 52,000 tonnes of dalo are produced annually and the value of the dalo industry is around \$120 million. According to the 2009 Agricultural Census some 40,000 farmers produced approximately 57,000 tonnes of dalo that was distributed to consumers as follows:

- Subsistence consumption 6,800 tonnes (12%)
- Domestic market sales 40,500 (71%)
- Export market sales 9,700 (17%)

The domestic market includes dalo sold by the roadside, local shops and municipal markets. The figures provided for the export market includes both fresh and processed dalo. Processed dalo includes peeled and cut frozen and fresh dalo, as well as dalo in other processed products (for example, dalo crisps). Fiji exports dalo to a range of countries, mainly Australia, New Zealand and the United States of America, with small volumes going to other markets including Canada and Europe.

Market trends

Demand for dalo is generally constant throughout the year, with an increase in demand by both domestic and export markets late in the year around Christmas. There is increasing competition in Fiji's export markets from dalo being produced by other Pacific countries. The consumers in these export markets are comprised mainly of expatriate Pacific Islanders.

Different Pacific Island communities have different preferences for dalo relating to taste, texture and appearance. Tausala ni Samoa is currently the preferred variety for fresh dalo exports, and is favoured by the Samoan community. Exporters tend to specify this variety if they are exporting fresh dalo. However, the variety Tausala ni Samoa is not as popular in the Fijian market. Traditional varieties, such as Uro ni vonu, have tended to be preferred by Fijians. Traditional varieties can have a shorter shelf life, making them better suited for sale as fresh dalo in the local market or for export as frozen product.

There are some anecdotes about changes in patterns of consumption in export markets. Young members of the Pacific Island community in export markets are reported to be increasingly interested in prepared dalo that is easier and quicker to cook. It is also possible that there are changes in variety preferences in this segment of the export market as tastes and lifestyles change.

Price is reported to remain a significant factor in determining sales in export markets. Fijian dalo must be competitively priced if it is to maintain or grow its share of export markets. Consistency of supply to these markets is also important, particularly after cyclones. After damaging cyclones export volumes can drop, and Fiji's market share is substituted by dalo from other countries. It can be difficult to rebuild this market share, so it is important that Fiji's dalo production is resilient to cyclones.

It can be difficult for information about export markets and market trends to be communicated along the value chain back to farmers. This can leave farmers confused about the volumes of export varieties they should plant. This confusion can be confounded by inconsistent quality requirements imposed by exporters and middlemen. During peak production periods, from November to May, middlemen and exporters tend to select the highest quality dalo, which in some situations can lead to a large proportion of the crop going to waste. During the off-season, from June to October, when there is limited availability of export varieties middlemen and exporters are currently in the habit of accepting much smaller dalo, immature dalo and are more tolerant of faults.

The path from farm gate to market

The export market and domestic market are relatively distinct markets. Because of taste preferences the varieties grown for export market are not sold in large volumes in the local market. Only dalo farmers close to large municipal markets are likely to be able to sell significant quantities of export varieties because they have a larger and more diverse market. In production areas outside of Viti Levu dalo crops of export varieties may not be harvested if exporters do not buy the dalo.

The business of collecting a shipment of dalo for export from farmers, processing it so it meets the quality standards of export markets, meeting any regulatory requirements and transporting the shipment is a complex one and needs to be done quickly and efficiently to ensure the dalo arrives in the export market in good condition. Delays in the supply chain can adversely affect quality by reducing the shelf life of the dalo. Export varieties may have a shelf life of 2 to 3 weeks if properly handled, whereas varieties preferred by the domestic market may only have an average shelf life of 7 days.

There are also a range of costs that accrue at different points in the value chain, and it can be difficult to appreciate how the price of dalo in an export market relates to the price being paid for dalo at the farm gate. Losses because of faults in quality and costs (from activities such as, handling and transport) can be difficult to track along the value chain.

Farming dalo for markets

Farmers planting dalo make a choice about the market they intend to sell to when they choose the varieties they plant and when they plant. Different markets prefer different varieties, and targeting off season production (i.e. harvesting from June to October) can result in good prices for quality dalo. The dalo corm is the main product from dalo crops, but dalo leaves and the suckers can also be harvested for sale.

Farmers incur a number of costs to grow dalo, which can include: planting material; herbicides and fertiliser; labour (planting, weeding, fertiliser application and harvesting); transport; leasing land. These costs can vary between farmers depending on how they manage their crops.

Farmer sell to middlemen/exporters at farm gate

The major pathway by which dalo is supplied for export is by middlemen or exporters purchasing directly from a farmer or group of farmers. Middlemen/exporters negotiate with farmers on the volume and price they will purchase at. This negotiation usually occurs when the dalo is ready for harvest. Farmers are usually responsible for harvesting the crop. When crops are harvested farmers and workers will tend to harvest plants that are healthy and that they think are most likely to meet the quality and size requirements of their buyers. Dalo is usually harvested the day before it is sold or delivered to the middlemen/exporters or at the local market. Farmers may need to transport the dalo to a particular collection point, or the middlemen/exporters may collect it from the farmers.

Dalo is usually sold to the middlemen/exporter based on meeting a size grade that the middlemen/exporter sets, and the corms are provided by the farmer as cleaned or semi-clean with the stem cut to a length of 2 inches, or 5cm. Middlemen/exporter make a check on quality when the dalo is being collected. Middlemen/exporters check dalo for defects, such as peanut shapes, maturity



of the dalo and damage from dalo beetle. The amount of dalo rejected on quality grounds can vary considerably. During periods of high availability middlemen/exporters tend to only buy the highest quality dalo being offered. Different middlemen/exporters have different quality requirements depending on the overseas buyers they deal with. An average estimate of the amount of dalo rejected by middlemen/exporters for quality issues is 10 to 15 per cent, but this vary considerably.

If a farmer does not sell the entire crop then they may sell the remaining dalo in local markets. Alternatively any remaining dalo might be distributed to workers, extended family or left in the ground.

Transport of dalo to the middleman/exporter

The arrangement for collecting and paying for the dalo, as well as details about particular quality requirements, cleaning, and transport of the crop are negotiated between the middlemen/exporter and farmer. The cost of transport will vary depending on where the dalo is grown. For example dalo supplied to an exporter based in Suva from Taveuni will need to be transported by road and ferry, whereas dalo supplied to the same exporter from Naitasiri only needs to be transported by road. These differences in transport prices may be reflected in the prices paid to the farmers by the middlemen/exporter. Prices and quantity very much depend on demand from the exporter.

The time taken for the harvested dalo to reach the packhouse can vary considerably. Dalo supplied to Suva based exporters from Naitasiri will arrive the same day it is collected, whereas dalo delivered to Suva from Taveuni or Koro will take at least one day to be shipped by road and sea to the packhouse. Longer periods of transport has the potential to cause damage to the dalo, especially if the journey includes significant distances over unsealed roads.

Farmers selling to local markets

Farmers or a group of farmers may arrange transport to take dalo and other produce to urban centres for sale. Farmers can sell dalo directly to customers in municipal markets on Fridays and Saturdays. From Monday to Thursdays farmers sell to permanent market vendors. The price and quantity of dalo sold to market vendors for resale depends on the vendor. Unless prices have been agreed beforehand farmers have to take the market price being offered.

In a small number of cases farmers with vehicles have also developed relationships with businesses and organisations in nearby towns and cities and they sell directly to staff in these organisations in response to weekly orders. Farmers also sell dalo at roadside stalls.

The prices achieved for dalo in local markets can be higher compared to dalo being sold for export, but the volumes sold are usually smaller.



The path from exporter to overseas markets

Dalo must be of high quality if it is being sent to export markets. Air freight is very expensive, and the cost can only be justified if the dalo is in excellent condition allowing it to be sold for premium prices so that the price of the air freight can be covered. Shipping by boat is less expensive than air freight, but still requires high quality. Bruises and damage to the dalo can cause rots to develop during the sea voyage leading to export consignments possibly being rejected or subject to costly treatments when they arrive in the market.

Receival and packing by the exporter

Once received at the packhouse the dalo is cleaned, trimmed and graded before being packed and stowed in refrigerated (reefer) containers. This process is usually done as soon as the dalo is received, with the aim that the process will be completed on the same day that the dalo is received.

Dalo received in the packhouse has usually already been checked for quality, but faults such as bruising and surface damage are found after cleaning as well as quality issues relating to size and shape. Estimates of the amount of dalo discarded during processing vary but was often described to be around 15 per cent.

Exporters usually have limited space to hold dalo for processing, and limited cold storage which means during peak supply they may be unable to buy the volumes of dalo on offer. Conversely there will be times during the year when exporters will be actively seeking out dalo from farmers so that they can ship the volumes of dalo that are demanded by their markets.

Some exporters process the dalo into a pre-prepared frozen product. Frozen dalo has advantages in that it has a much longer shelf life, is easy for consumers to handle and prepare, and avoids the biosecurity issues for fresh dalo. However, it is not currently as well accepted by the market as fresh dalo. Food manufacturing companies in Fiji may also purchase dalo from exporters to produce “value added” processed products, such as dalo chips.

Arrangements for export

Exporters will use either sea freight or air freight to transport dalo to export markets. Exporters have to coordinate closely with air and sea freight handlers in order to make sure they meet deadlines for transport. Most exporters work to a weekly schedule sending a shipment of dalo to each of their export markets by air or sea freight (or in some cases both) once a week. Depending on when the boat or plane is leaving for the export market the exporter may hold the dalo in cool storage for 2 or 3 days. The dalo for export requires biosecurity inspection and certification before being transported to the port. Once cleared the containers may be washed before loading them onto the ships.

The time taken for sea freight to arrive depends on the market. Trips to ports in New Zealand are reported may take between 3 to 7 days. This means that dalo sent by sea freight may arrive in the market 1 or even 2 weeks after harvesting. Shipping delays can be problematic, as the quality of the dalo reduces over time which may lead to lower prices and shipments being rejected by biosecurity officials or overseas buyers. Once dalo shipments arrive they then need to be cleared by biosecurity officials in the receiving country.

It is possible to use air freight to get to dalo to export markets the day after it leaves the exporters premises, landing in the export market within 4 to 5 days of harvesting. Air freight is very expensive and can only be justified if a premium price can be achieved.





Costs associated with the export of dalo

A Cost Analysis of Root Crop Exports from Fiji published in 2018 looked at the different costs incurred along the supply chain of dalo being prepared for export to New Zealand. This survey found that, at the time of the study, the largest cost incurred was the purchase of dalo from farmers (76% of the cost to export one container). Ocean freight costs were the second largest cost (10.9%) followed by packhouse costs (4.8%) and costs to transport the dalo to the packhouse (3.7%).

The study indicated that the profit margins of exporters were relatively small, and that small variations in the cost of purchasing dalo from farmers or the cost of insurance and freight to land the dalo in Auckland had a significant impact on the viability of business for exporters.

Source: Young, D. and Gonemaituba W. (2018) "Cost Analysis of Root Crop Exports (TR#118)" Report for the Pacific Horticultural and Agricultural Market Access (PHAMA) Program



Manual overview

Summary of good agricultural practises to support quality dalo production

Site selection and preparation

Site selection and preparation can influence how healthy the dalo plant is. This influences the size of the dalo corm at harvest, helps ensure it is an even shape, and can help avoid pests and diseases.

- Good moisture availability throughout the year, past crops, potential for erosion and access to transport are things to consider.
- It is important that there is adequate drainage and the soil is not overworked.
- Crop rotations help maintain soil fertility and can reduce the incidence of pests and diseases.

Variety selection

Dalo variety selection is important. Different customers may have preferences for different varieties, and different varieties respond differently to pests, diseases and growing conditions.

A customer might want a particular variety because of the way it tastes and they might be familiar with how that variety needs to be prepared and cooked. Supplying a particular variety is particularly important with fresh and frozen dalo in export markets where the customer cannot check the variety for themselves.

- The varieties planted by a farmer will in part depend on the market that the farmer is intending to sell the dalo to.
- Different varieties have different characteristics, and farmers should be familiar with how different varieties perform on their farms and which gives the best production and quality.

Propagation and planting

The planting material used to propagate the dalo plants can influence the health of the plants. Healthy propagation material that is planted and looked after with care will produce better yields of quality dalo.

Planting material

- Only use healthy suckers of a similar size to help produce a crop of consistent size and quality. Suckers should be 4cm in diameter and trimmed so that 20-30cm of the leaf stalk remains.
- Suckers should be carefully stored prior to planting. Under ideal circumstances they should be stored in a covered, ventilated area and kept off the ground. This helps to maintain their condition, allow wounds to heal before planting and reduce the likelihood of damage from pests and diseases.
- Use dips where appropriate to prevent dalo beetle and other pests and diseases, and do not use diseased suckers.

Planting time

- When planting a crop it is useful to consider when it will be ready for harvest and what the market for the crop will be. Will there be lots of dalo on sale that might reduce the price?
- Planting time has implications for quality, particularly the shape of the corm in drier rainfall areas. Growth during dry times can result in dalo with irregular shapes. Irrigation may be useful to help improve consistency of shape and production.

How to plant

- It is important that the corm is planted at the right depth so that it grows healthily and develops a good shape.
- Ministry of Agriculture field staff can assist farmers with advice about row spacing and planting density, and farmers should experiment further to determine the best spacing for their farm and the varieties that they use.



Fertiliser use

All crops remove nutrients from the soil, and it is important that the nutrients used by the crops are replaced. Fertiliser application can improve dalo quality and yields by improving growth and the resilience of dalo plants to disease. However, fertiliser can be expensive and needs to be used with care. There is increased interest in organic farming systems and the use of alternative fertilisers.

- Year-on-year cropping of dalo depletes soil nutrients and this needs to be balanced with strategies to replace the soil nutrients used by a crop.
- Fertiliser needs to be applied in correct quantities and at the right time during the season to avoid irregularly shaped corms. Soil testing can help understand what fertiliser might be needed.
- Ministry of Agriculture field staff can assist farmers with information about fertiliser strategies in different districts as well as alternative practises, such as organic farming.

Weeds, pest and disease management

Weeds, pests and diseases can reduce the health and productivity of dalo plants, reducing yield. Pests and diseases also cause damage to the dalo corm reducing its quality and can reduce the storage life of the harvested dalo. Pest and disease damage can also make dalo corms harder to clean.

Weed control

- Dalo crops need to be kept free of weeds, particularly during the first four months of their growth.

Pests

- Crops should be inspected for pests, particularly dalo beetle, to ensure that they are not causing problems.
- The best approach to managing pests is to try to avoid outbreaks by rotating crops, and avoiding nutrient or water stress which might make the crop susceptible to pests.

Diseases

- Crops should be regularly inspected for diseases along with pests that might spread disease.
- Parts of diseased plants should not be used for planting material. Plants with signs of virus should be removed from a crop to prevent spread of the virus.

Keeping farm records

Keeping farm records helps to understand how changes to farm practises influences quality and yields and regularly reviewing farm records can help to identify ways to improve the yield and quality of crops over time.

Managing farm workers

Farm workers can influence the quality of the crop through their work in planting and maintaining the crop and during harvest. It is important to clearly explain to workers what needs to be done to ensure the crop is productive and of high quality.

Good harvest and post-harvest handling practises on farm

Correct harvesting is critical to good quality dalo. Harvesting and handling the corms after harvest needs to be done with care to avoid damaging the dalo and maintain its quality. Dropping or throwing dalo, over packing and mishandling sacks of dalo and poor storage of dalo are all damaging practises that must be avoided. Damage from poor handling might take 3 to 5 days to appear, so it is possible that any bruising or internal damage that occurred at harvest or during any subsequent transport and handling may not be visible after the dalo has been exported. It is important that poor quality dalo is discarded at harvest, as it can be the source of secondary rots in the harvested dalo.

Timing of harvest

- Dalo should only be harvested when it is fully mature, and only healthy plants should be selected for harvest.

Harvesting dalo crops

- Corms should be harvested in the cooler parts of the day.
- Harvested corms should be moved with care to the collection point and dalo should never be dropped or thrown.

Cleaning, sorting and preparation in the field

- Excess soil and plant material should be removed from corms at the time of harvest.
- Corms that are physically damaged or have symptoms of rot or pest infestation should be discarded to prevent the spread of pests and diseases and improve the shelf life of the crop.
- Headsets should be trimmed to a length of approximately 5 cm at the time of harvest.
- Middlemen and exporters should clearly describe what quality and size standards they require prior to collecting the dalo.

Storing dalo prior to collection

- Corms should be stored in a dry, shady location, and in a way that will prevent contamination with pests, weed seeds or other things that might damage the dalo or require more cleaning and processing.

Grading for quality

Harvested dalo is usually graded at the farm before it goes to market or is collected by middlemen or exporters. Dalo is checked to make sure that it meets requirements of the exporter for size and shape, that it is the correct variety, and that it is free from damage, pests or diseases.

- It is important that middlemen and exporters clearly explain the quality and size requirements for dalo they are looking to purchase prior to coming to collect or accepting the delivery of the harvested crop. Different middlemen/exporters can have different quality requirements.

Transporting dalo to local markets

When dalo is to be sold in local markets it is important that it is handled with care and arrives at market in good condition. Dalo in good condition is likely to achieve higher prices and will also last longer, which is an advantage for stall holders selling the dalo and for customers.

- Corms should be handled gently during loading and unloading to minimise physical damage to the corms. Bags of dalo should always be placed on the ground, never be thrown or dropped.
- Load and stack the dalo in transport vehicles in a way that will reduce the risk of damage to the corms. This is particularly important if the trip to market is over rough roads.
- Cover the corms during transport to prevent damage and contamination. A light coloured covering will also help to prevent the dalo from getting hot.
- When the dalo is put on display for sale it should be in a shady location where it is protected from the elements.



Summary of good handling practises for export quality dalo

Transport between farms, middlemen and exporters

Transport can damage dalo, reducing quality. Care needs to be taken to reduce the potential for damage to occur wherever possible.

- Corms should be handled gently during loading and unloading to minimise physical damage to the corms. Load towards the front of the truck if possible, as this area is less prone to excessive in-transit damage. Prior to loading trucks should be parked in the shade where possible to avoid the truck getting hot and prevent heat damage to the dalo.
- Where polypropylene sacks are used they should be loaded and stacked in a manner that will reduce the risk of damage (crushing, for example) to the corms. Wooden or plastic crates and field bins can be a better option as they may be stacked to reduce crush damage to the dalo. Dalo should not be loaded as loose corms in the back of vehicles.
- If sacks are re-used they should be clean. Avoid using sacks that have been used to contain chemicals (for example fertiliser) as this creates a food safety hazard. There is also a risk that sacks that have been used to carry dalo and other root crops may also spread disease between farms.
- Corms should be covered during transport to prevent contamination with weed seeds and insects. It is recommended that a light-coloured covering is used to minimise heat absorption in the load. It is always preferable to use a truck with a canopy.
- During transport the smoothest route possible should be chosen to lessen the risk of physical damage to corms.

Sorting and processing by middlemen

Middlemen have a role in grading dalo to help ensure that shipments are of consistent size as well as checking dalo quality. It is important that this handling does not result in damage to the dalo and a decline in quality prior to the dalo being transported to the processor or exporter.

- Corms should be handled gently during unpacking, grading and repacking to minimise physical damage.
- Any corms that are deformed, damaged, under- or over-sized, infested or have symptoms of rot need to be removed during grading.
- Corms should be repacked into clean packaging material to minimise the risk of contaminating the graded corms.
- Dalo corms graded as suitable for export should be kept separate from other dalo.
- Where polypropylene sacks are used, they should be packed to a maximum weight of 30 kg to enable careful handling of the sacks.
- Graded and repackaged corms should be held in a cool, well-ventilated location that is protected from the elements and free from contaminants.

Processing in packhouses for export

Processing should ensure that the dalo is cleaned and presented so that it is attractive to customers in export markets and that the dalo meets biosecurity requirements of those markets. Care needs to be taken to avoid damaging the dalo, but also that the cleaned and graded dalo does not become contaminated. Exporters may consider implementing systems that can allow trace back of exported dalo through the supply chain to identify where poor handling practises have occurred and reduce the possibility of future losses. Carefully processed dalo can avoid costly, time-consuming and potentially damaging biosecurity treatments in export markets.

Receival

- Corms should be handled gently during unloading and unpacking to minimise physical damage to the corms.
- Export dalo corms must be segregated from non-export corms at all times.

Trimming corms

- To meet Australian import requirements the tops of the dalo (including petiole bases) need to be removed, along with any lateral buds, shoots and corms. Extraneous root material is also removed, usually by peeling.
- To meet New Zealand import requirements it is general practise to trim the tops of the dalo with a clean, straight cut to a length of 5 cm. Extraneous root material is then removed from the corm, often leaving some of the skin on the surface of the dalo.

Washing of corms

- Corms must be washed in clean water to remove all soil, insects, and extraneous plant material. Use pressurised water or soft brushes as necessary.
- Corms must be visually inspected during washing and any corms that do not meet export quality or biosecurity requirements must be removed from the pathway.

Grading and inspection

- In addition to grading to ensure the dalo meets biosecurity requirements exporters will have their own grading system to meet the requirements of agents and customers in the export market.

Processing for freezing or use in manufactured foods

- The process of freezing or manufacturing cannot “improve” the quality of the dalo. Good quality dalo is always the starting point for good quality frozen or manufactured products.
- The same care and attention required for fresh dalo is also relevant for maintaining dalo quality when processing dalo for freezing or using it for manufacture into other foods.

Drying and conditioning

- Following washing, corms must be moved to a contaminant free area for drying. Corms should be placed on a clean rack that allows adequate air circulation around the corms.

Packaging

- New, clean, packaging must be used for export dalo. Packages must be sewn or tied closed and labeled. Prior to loading, store packaged corms in a clean area free from pests and other contaminants.

Final inspection

- A final inspection must be undertaken following packing. Any corms that do not meet export quality or biosecurity requirements must be removed from the export pathway. The use of low power magnification to investigate suspect corms is recommended. Inspection records for each consignment of dalo must be retained.

Storage

- Sea and air containers must be free of soil, insects and other contaminants prior to packing. Ensure air containers are sealed to prevent the entry of pests and other contaminants.
- Maintain refrigerated containers at 8 - 10°C during storage and shipping.



Good agronomic/ agricultural practises



Growing dalo for export

Discussions with farmers during the development of this manual highlighted a number of lessons farmers had learnt in producing good quality dalo for markets. Farmers felt it was important to be committed to producing dalo for export or local markets, and good crop husbandry and monitoring the crop was critical to produce good quality dalo. Farmers felt it was important to be diligent in tending crops throughout the season, but also to experiment and try new practises that could improve production and quality. Some farmers observed that practises and varieties that might work well in one area might not work as well in other locations.

Site selection and preparation

Site selection and preparation can have an impact on how healthy the dalo plant is, which in turn influences the size of the dalo corm at harvest, helps to ensure it is an even shape, as well as helping to avoid pests and disease which can reduce the quality of the harvested dalo.

The Ministry of Agriculture provides general advice and recommendations in relation to site selection, crop rotation and fallowing for planning dalo production. It is important that farmers talk regularly to Ministry of Agriculture on the latest advice regarding this.



Site selection

In general fertile, well-drained, deep loamy soils rich in organic matter are preferred for dalo production. Flat to gently sloping sites with alluvial soils in river valleys are often used. Steep slopes (>15° incline) should be avoided as they are prone to erosion and difficult to manage. Wet and high rainfall areas are particularly sought after as they allow dalo to be grown year round, allowing the farmers to supply local markets and exporters during the 'off season' when prices can be relatively high. In intermediate rainfall areas dalo can usually only be grown from September to March when there is sufficient moisture in the soil. Dry periods without irrigation can lead to odd shapes (such as peanut or dumbbell shapes), which are unsuited to export as fresh dalo. Oddly shaped dalo is difficult to clean in order to meet the requirements of export markets, and they are not as attractive for customers.

Quality issues caused by water scarcity can be addressed through irrigation. Irrigation has advantages in that it can help support year round dalo production, and can improve quality in some circumstances, but it requires access to a suitable water source, an investment in infrastructure as well as time and energy to establish and maintain the irrigation system.

In some places there are risks that dalo could be contaminated from pollution in the soil, air or water by hazardous chemicals. Past land uses, such as if the area had been planted with a crop of dalo previously may also have an impact on pests and diseases and the eventual quality and quantity of dalo harvested from the site.

Care should also be taken to ensure that dalo crops are not planted too close to streams so that any pesticides or fertilisers applied to the crop are not washed into the water and pollute waterways. When looking for new planting sites it can be useful to do soil testing to help understand where the most fertile location is.

When planning to plant dalo it is important to think about transport and how the crop will be collected when it is harvested. Difficult access and a lack of paths make it difficult to move the crop resulting in damage and rough handling at harvest. This problem can be made more difficult if hillslopes are being harvested. Finding a site close to a road which will allow access for trucks to collect the crop will make harvesting easier and reduce damage to the crop.

- Site selection should consider consistent moisture availability, past land uses, potential for erosion and access to transport.

Site preparation

Soil on the dalo patch needs to be loosened by digging with fork or by ploughing and harrowing. If mechanical methods are used to prepare the land care should be taken to reduce the likelihood of soil compaction which can damage the soil and may result in yield decline over time.

On the flat land drains may need to be built using bullocks or tractor to allow any excess water to drain away. It is best not to plant dalo in waterlogged soil as this may result in corm rot.

- Sites should be prepared to ensure there is adequate drainage and care taken not to overwork soil.



Crop rotations

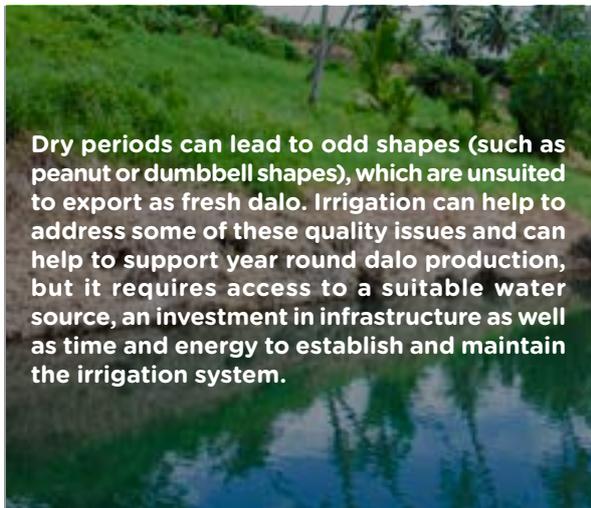
Continuous cultivation of dalo on the same land year after year can lead to problems with declining soil nutrition and a build-up of pests and diseases. This results in decreased corm sizes over time and reduced yields. The Ministry of Agriculture can provide advice on appropriate crop rotations to use with dalo, along with fallow periods without crops and other practises such as the use of green manure crops. Crop rotations can assist in decreasing soil pests and may improve soil nutrition. In some locations invasive weeds, such as African Tulip, make it difficult to use fallow periods as the weeds overtake the farmland and are difficult to control.

In some areas dalo is planted in conjunction with yaqona (kava), as it can provide shade for the young yaqona plants as they become established. Dalo can also be grown under coconuts and other tree crops as it tolerates some shading.

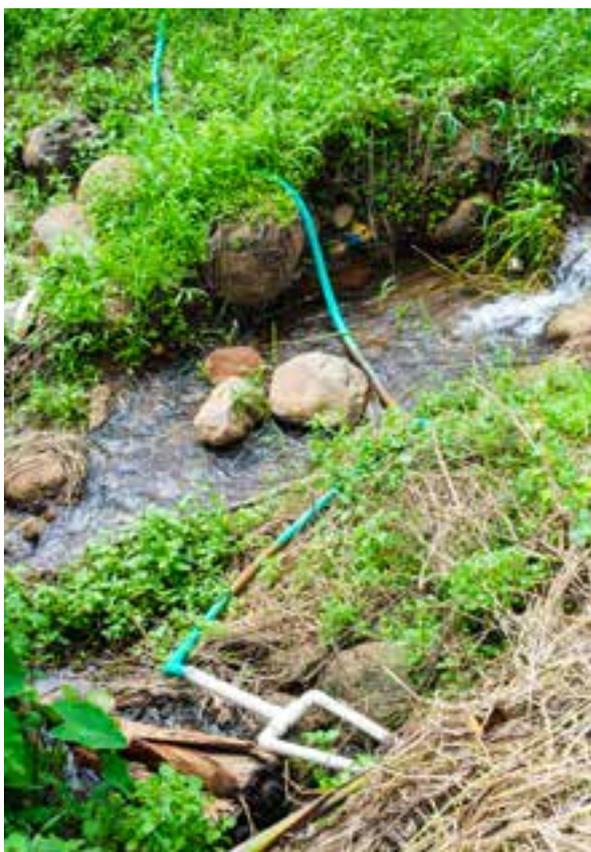
Work has been undertaken by the Ministry of Agriculture on the use of Mucuna bean (*Mucuna pruriens*) as a fallow and a cover crop. Based on results of this work the Ministry of Agriculture has been promoting the use of Mucuna bean to suppress weeds and nematodes, improving the health of the dalo crop. The benefits from weed suppression can have cost savings for farmers in reducing labour requirements and reduced need for weedicides. Mucuna is also promoted as being able to increase soil fertility through encouraging biological process in the soil resulting in improved yields.

- Crop rotations are important for maintaining soil fertility as well as reducing the incidence of diseases and the build-up of pests in the crop.





Dry periods can lead to odd shapes (such as peanut or dumbbell shapes), which are unsuited to export as fresh dalo. Irrigation can help to address some of these quality issues and can help to support year round dalo production, but it requires access to a suitable water source, an investment in infrastructure as well as time and energy to establish and maintain the irrigation system.





Variety selection

Variety selection is important. Customers may have preference for a particular variety, but different varieties vary in their resistance to pests and diseases and tolerance for different growing conditions.

Customers are interested in the variety because they want to be familiar with how the dalo needs to be prepared for cooking and what the dalo will taste like when they cook it. This is particularly important in export markets where dalo is sold pre-prepared or in a form where the customer cannot check the variety for themselves.

There are a large number of dalo varieties in Fiji. Many of these varieties are not commercially important but may have particular taste or agronomic characteristics that make them useful (for example disease resistance and tolerance to poor conditions). The Ministry of Agriculture maintain a collection of over 100 varieties which are used to breed new varieties that are resistant to disease or better suited to market or farmer requirements. Over time there are changes in the types of varieties grown as consumer tastes change and new varieties are released by the Ministry of Agriculture.

There are a number of different characteristics that are used to distinguish between the different varieties. Descriptions of the dalo varieties usually refer to the appearance of the variety when it is mature as characteristics of the leaves and corm may be difficult to distinguish until the plant becomes 'full sized'. Examples of features used to tell dalo varieties apart include: the size, colour and shape of corms; the number of suckers produced, how they attach to the corm including if they are produced on stolons (stems); if the corms tend to branch; the colour of the petioles; and the size, shape and colouration of leaves. Determining varieties can be difficult as a variety may have a different appearance when grown under different conditions.

Farmers can choose to plant different varieties for a range of reasons. A farmers might choose a particular variety because it is best suited to the conditions of the area. Alternatively a farmer might choose to grow a particular variety because it sells well in the local market or exporters have indicated they prefer the variety. The choice of variety can have significant implications for the quality of the dalo harvested.

From a farmers perspective some varieties may be better able to resist water logging or dry periods, and some varieties have shorter seasons which might help production in dry areas. Similarly some dalo varieties are more resilient to pests and diseases. If season length and pest and disease infestations are an issue then farmers would be best advised to discuss variety selection with Ministry of Agriculture staff.

Dalo varieties have a range of different colours and eating qualities that influence customer preferences. Many customers will prefer varieties with particular tastes, textures and colours. In export markets customers with Pacific Island heritage will tend to prefer varieties that have similar eating qualities to the dalo grown in their homeland. For example Tausala ni Samoa is a variety often preferred by Samoans living in New Zealand and there is some demand for Uro ni vonu by Fijians living overseas. Shelf life is an important consideration for dalo being exported, and varies between dalo varieties. Shelf life refers to the length of time that the dalo retains a good taste and texture.

Dalo breeding programs seek to develop varieties that have good agronomic characteristics and have taste and texture characteristics that are attractive to consumers. Another characteristics that are sought after include dalo retaining some softness after it has been cooked rather than becoming hard.

- The varieties planted by a farmer will in part depend on the market that the farmer is intending to sell the dalo to.
- Different varieties have different characteristics, and farmers should be familiar with how different varieties perform on their farms and which varieties produce the best production and quality.

Description of Fijian dalo varieties for export and important local varieties

MAIN EXPORT VARIETIES



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VARIETY

Tausala ni Samoa

ALTERNATIVE NAMES

Fiji Pink, Tausala

COMMON DESCRIPTIVE FEATURES

Leaf

Green with undulate leaf margin

Petiole colour

Green with slight brownish on the apex

Petiole base colour

Pink coloration

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Conical, medium size, white flesh colour

AGRONOMIC ATTRIBUTES

Susceptible to dry seasons, may need to be irrigated to maintain quality for export.

Doesn't have stolons & can be easily identified amongst other dalo varieties if are grown together

Relatively short growing season, can be harvested from as early as 5-6 months after planting

OTHER FACTORS

Long shelf life.

Has been the preferred fresh variety of Samoan communities in the New Zealand and Australian export markets.

Greyish to dark greyish cooked.



VARIETY

Samoa Hybrid

ALTERNATIVE NAMES

Samoa

COMMON DESCRIPTIVE FEATURES

Leaf

Green, entire leaf margin, with dark spot in the mid rib

Petiole colour

Light purple petiole color

Petiole base colour

White petiole base

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Long elliptic corm, medium size corm and white flesh color

AGRONOMIC ATTRIBUTES

A hybrid variety.

Can tolerate some dry conditions.

Harvested at 7-8 months after planting with very good eating quality

OTHER FACTORS

Short shelf life.

Good eating quality.

Was once a preferred variety in Fiji in the 1990s.

Greyish when cooked.

MAIN EXPORT VARIETIES



34

VARIETY

Wararasa

ALTERNATIVE NAMES

Rewa, Maleka dina

COMMON DESCRIPTIVE FEATURES

Leaf

Green, undulate margin, slight dark spot in the mid rib

Petiole colour

Green with slight brown stripes & light brown at the apex

Petiole base colour

White

Type of suckering

Have stolons or running suckers

Corm shape, size & flesh colour

Long, elliptical shaped corm, bigger corm sizes, light yellow flesh colour

AGRONOMIC ATTRIBUTES

A hybrid variety, and one of the more commonly grown dalo varieties in Fiji.

Adapted to various conditions in Fiji including dry conditions, and has some resistance to waterlogging.

Matures in 7 - 9 months.

OTHER FACTORS

Short shelf life, mostly exported as frozen.

Good eating quality.

Light yellow when cooked.

Wararasa has stolons or running suckers.





VARIETY

Maleka Dina

ALTERNATIVE NAMES

--

COMMON DESCRIPTIVE FEATURES

Leaf

Light green, entire leaf margin, no dark spot in the mid rib

Petiole colour

Green with red stripes on the petiole, apex of the petiole is green

Petiole base colour

Red with white coloration

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Conical corm shape, medium size corms and slight yellow flesh color

AGRONOMIC ATTRIBUTES

A hybrid variety and thrives well on fertile soil, medium size plants and can be easily identified by petiole colour and leaf characteristics.

Matures in 7 - 9 months.

Susceptible to prolonged dry spells.

OTHER FACTORS

Short shelf life with excellent eating quality.

Yellowish when cooked

MAIN EXPORT VARIETIES



36

VARIETY

Vula Ono

ALTERNATIVE NAMES

--

COMMON DESCRIPTIVE FEATURES

Leaf

Dark green and larger leaves, dark mid rib, entire leaf margin

Petiole colour

Bigger petioles, green and brownish towards the apex

Petiole base colour

Red stripes with white coloration

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Bigger corm sizes, long elliptic corm shape, slight yellow flesh colour

AGRONOMIC ATTRIBUTES

Hybrid variety with vigorous growth habit and large leaves.

Some tolerance to dry conditions.

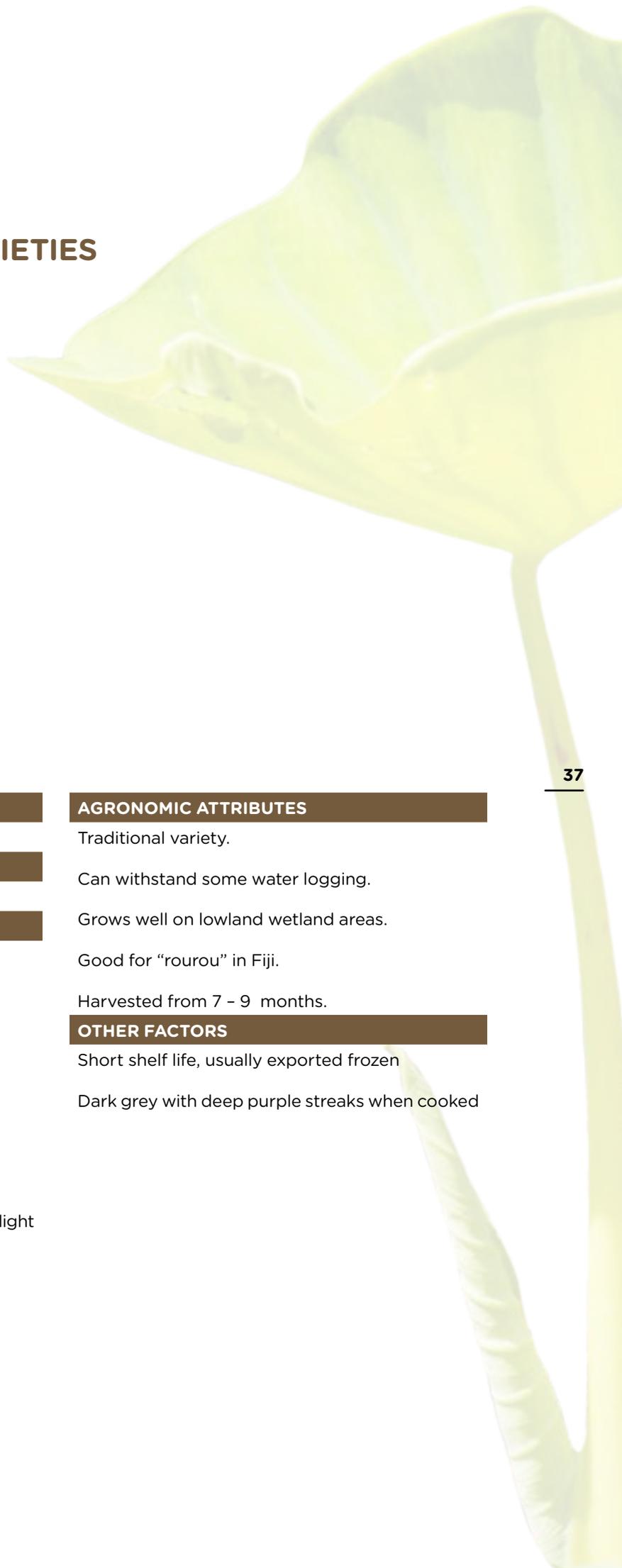
Matures in 8 - 10 months, and corms start to loose condition after 9 months.

OTHER FACTORS

Short shelf life with very good eating quality.

Slight yellow when cooked

MAIN TRADITIONAL VARIETIES



VARIETY

Uro ni vonu

ALTERNATIVE NAMES

Moala, Black dalo

COMMON DESCRIPTIVE FEATURES

Leaf

Light purple, undulate leaf margin

Petiole colour

Dark purplish petiole

Petiole base colour

Slight purple and white coloration

Type of suckering

Stolons or running suckers

Corm shape, size & flesh colour

Long elliptic corm shape, medium size corms, light purple yellow flesh colour

AGRONOMIC ATTRIBUTES

Traditional variety.

Can withstand some water logging.

Grows well on lowland wetland areas.

Good for “rourou” in Fiji.

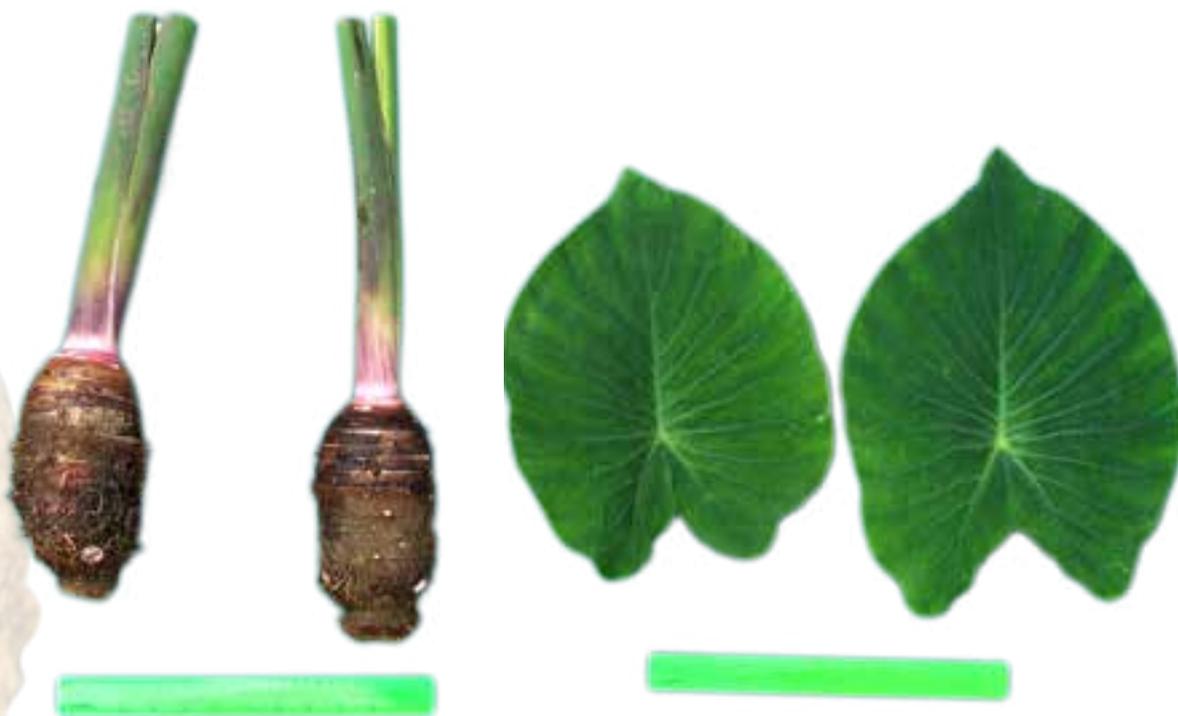
Harvested from 7 - 9 months.

OTHER FACTORS

Short shelf life, usually exported frozen

Dark grey with deep purple streaks when cooked

MAIN TRADITIONAL VARIETIES



38

VARIETY

Vavai dina

ALTERNATIVE NAMES

Vavai ni Viti

COMMON DESCRIPTIVE FEATURES

Leaf

Green with entire leaf margin

Petiole colour

Green with slight brown at the apex

Petiole base colour

Purplish

Type of suckering'

Suckers attached

Corm shape, size & flesh colour

Conical corm shape, medium size corms, white flesh colour

AGRONOMIC ATTRIBUTES

Traditional variety.

Can tolerate water logging. Grows well on lowland wetland areas.

Vavai varieties do branch in certain conditions; this is the characteristic of this variety.

Harvested from 7 - 9 months.

OTHER FACTORS

Short shelf life and very good eating quality.

Greyish when cooked



VARIETY

Vavai loa

ALTERNATIVE NAMES

--

COMMON DESCRIPTIVE FEATURES

Leaf

Green with entire leaf margin

Petiole colour

Dark purple

Petiole base colour

Purplish

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Conical corm shape, medium size corms, white flesh colour

AGRONOMIC ATTRIBUTES

Traditional variety.

Can tolerate water logging. Grows well on lowland wetland areas.

Vavai loa forms branches in some conditions.

Harvested from 7 - 9 months.

OTHER FACTORS

Short shelf life with very good eating quality

Greyish when cooked.

MAIN TRADITIONAL VARIETIES



40

VARIETY

Samoa dina

ALTERNATIVE NAMES

Samoa

COMMON DESCRIPTIVE FEATURES

Leaf

Green with undulate leaf margin

Petiole colour

Lighter-dark purple petioles with white flesh colour

Petiole base colour

White

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Long elliptic corm shape, medium size corms and white flesh color

AGRONOMIC ATTRIBUTES

Traditional variety.

Can withstand prolonged dry conditions.

Grows well on fertile, loose soil.

Harvested in 7 - 10 months.

OTHER FACTORS

Short shelf life with good eating quality.

Greyish when cooked.

**VARIETY**

Kurokece

ALTERNATIVE NAMES

--

COMMON DESCRIPTIVE FEATURES**Leaf**

Light green, soft and undulate leaf margin

Petiole colour

Light green

Petiole base colour

White

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Conical corm shape, medium size corms and white flesh colour

AGRONOMIC ATTRIBUTES

Traditional variety.

Common in highlands and forest conditions, leaves are soft and good for "rourou".

Name kurokece means all can be cooked, meaning all parts of the plants is edible.

Matures in 8 - 10 months.

OTHER FACTORS

Better shelf life and very good eating quality.

White when cooked with soft texture.

MAIN TRADITIONAL VARIETIES



42

VARIETY

Dalo ni Toga

ALTERNATIVE NAMES

Toga

COMMON DESCRIPTIVE FEATURES

Leaf

Green with undulate leaf margin, with dark spot in the mid rib

Petiole colour

Green with light reddish to the apex

Petiole base colour

Pink base and white around the base

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Long elliptic corm shape, medium to large corms, white flesh colour

AGRONOMIC ATTRIBUTES

Traditional variety.

Can branch, producing two tops with one common corm.

Can be grown in semi wetland areas.

Harvested at 8 - 10 months.

OTHER FACTORS

Short shelf life with excellent eating quality

White colour when cooked.



VARIETY

Toakula

ALTERNATIVE NAMES

--

COMMON DESCRIPTIVE FEATURES

Leaf

Green with undulate leaf margin and black spot in the mid rib

Petiole colour

Pink

Petiole base colour

White at base of petioles with distinctive reddish-pink petioles with white flesh colour

Type of suckering

Suckers attached

Corm shape, size & flesh colour

Long elliptic corm shape, medium corm sizes and white flesh colour

AGRONOMIC ATTRIBUTES

Traditional variety.

This variety can be easily identified due to its pink petioles.

It produces few suckers.

Best adapted to some lowland areas.

Harvested at 8 - 10 months.

OTHER FACTORS

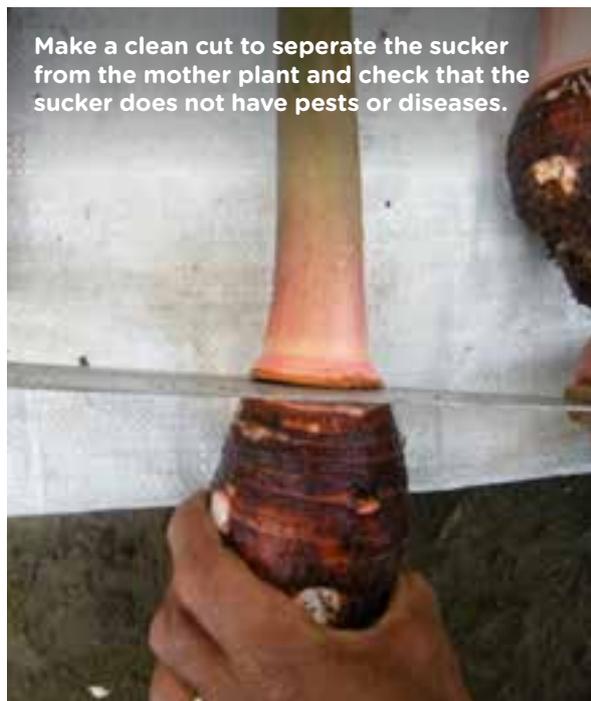
Short shelf life with good eating quality.

White when cooked.



Propagation and planting

The planting material used to propagate the dalo plants can influence how healthy the plants and the yields achieved from the dalo crop. Healthy dalo crops begin with healthy propagation material that is planted and looked after with care. Healthy dalo crops can be expected to produce better yields of quality dalo.



Make a clean cut to separate the sucker from the mother plant and check that the sucker does not have pests or diseases.



Planting material

Good quality planting material helps to produce a good quality dalo crop. Dalo is usually propagated from tops and suckers. The healthiest planting materials should be used to help achieve the best yields and help ensure a uniform sized crop. Healthy suckers usually establish faster and grow vigorously to form canopy. A good canopy helps to reduce weed growth and makes the management of weeds easier later in the season.

Different dalo varieties can produce suckers in two different ways. In some varieties suckers grow directly from the corms, and some varieties produce short stolons or “runners” and suckers are produced on the runners that form above the soil. On varieties where suckers grown directly off the dalo corms it is important that the suckers are not removed before the crop is ready to harvest. Pulling immature suckers from dalo plants can cause wounds on the mother dalo plant that can cause rots. It is better practise to wait until the mother dalo plants are harvested to prevent damage and rots. Where suckers are produced on runner it is possible to collect suckers before harvesting the mother plant, as the wounds caused by harvesting the sucker on the runner are less likely to be infected by rots.

The leaves of planting material should be free of splotching colour and marks that might indicate disease infections. If planting material is being brought in from another area care needs to make sure that it is free from pests and diseases.

The suckers should be sorted into groups of similar sizes, and suckers that are approximately 4cm in diameter should be kept for planting. The tops of the suckers should be cleaned to remove any dead leaves and trimmed so that 20-30cm of the petiole (the stem attached to the leaf) remains. The lower part of the sucker root should also be cut off so that only the top 5cm of the root remains, any excess or dead roots removed. The total length of the sucker, including the cut petiole and part of the root will be around 25-35cm.

The tops of harvested corms and corms larger than 4cm in diameter are generally unsuitable to be used as planting material for export dalo as they may produce irregular shaped dalo corms, or corms without the desirable rounded shape.

The suckers should be stored in a shaded, dry, cool and well-ventilated area for 3 to 5 days before planting. This should allow the wounds on the sucker corm to dry and heal before planting. Suckers should be stored off the ground to ensure they do not become infested with dalo beetle or other pests. Suckers that have been left for too long and that have become wilted and soft should not be used.

In areas infested with Dalo (Papua) beetle it is important that the planting material used is clean and healthy. This way the suckers can establish quickly and this can help reduce damage from the beetles. The Ministry of Agriculture can provide advice about appropriate treatments, such as dips, to prevent dalo beetle and other pests and disease. It is important that the planting material is treated with dips before it is transported to avoid spreading pests and disease.

- Only use healthy suckers of a similar size to help produce a crop of consistent quality. Suckers should be 4cm in diameter and trimmed so that it has 20-30cm of the petiole and 5cm of root.
- Suckers should be carefully stored prior to planting. Under ideal circumstances they should be stored in a covered, ventilated area and kept off the ground. This helps to maintain their condition, allow wounds to heal before planting and reduce the likelihood of damage from pests and rots.
- Use dips where appropriate to prevent dalo beetle and other pests and diseases, and do not use diseased suckers.



Planting time

In intermediate rainfall areas it is possible to plant from July through to January. Yields are likely to be best when planting is done at the beginning of the rainy season and the dalo is given the greatest chance to mature. In wet areas planting is possible throughout the year.

Farmers regularly growing dalo for the export market often use a phase planting approach, and aim to plant dalo each month throughout the year so that they can provide dalo to exporters year round.

In the cooler, drier months of the year (for example May to August) dalo crops in intermediate rainfall areas are still growing and they are generally not suitable for harvest. This is a period when there can be relatively low availability of dalo and prices paid in the local market and by exporters can be higher. By careful timing of planting and potentially using shorter season varieties it may be possible for farmers to produce dalo to service this period of low supply by growing dalo in the wet areas or using irrigation in drier areas. Demand also lifts around Christmas, and through carefully managed planting it is possible for farmers to target this market.

Because the dalo plants grow upwards from the planted piece of corm periods of stress on the plant, such as damage from winds or drought, can result in the shape of the corm becoming distorted. Where possible planting time and varieties should be chosen so that the dalo will grow evenly and mature whilst the soil has adequate moisture. Distorted and peanut shaped corms are regarded as poor quality. Irrigation can help address these quality issues in some locations.

If farmers are looking to supply middlemen and exporters, particularly to target the off-season supply, they should discuss a planting calendar (scheduling monthly plantings) with their middlemen/exporters to help provide consistent supply. It is also useful to understand the likely demand from the middlemen/exporter when planting at the beginning of the season to help avoid over or under supply.

- Planting time has implications for quality, particularly the shape of the corm in intermediate rainfall areas. Irrigation may be useful to help improve consistency of shape and production.
- When planting a crop it is useful to consider when it will be ready for harvest and what the market for the crop will be.



How to plant

Planting dalo in orderly rows makes it easier to maintain the crop and carry out weeding and fertilising during the season. Ministry of Agriculture field staff can assist farmers with advice about row spacing and planting density, however it is likely that farmers will have to experiment for themselves to find the best spacing as this will vary between farms. Different varieties perform differently at different spacings, and soil type, slope and rainfall also influence productivity and choice of plant spacing. In dryer areas (such as hillslopes) yields and quality may improve by slightly increasing spacing between plants so that there is less competition between plants for water. In wet areas it may be possible to plant the dalo closer together.

Holes are dug to a depth of 25cm deep by hand with a spade or planting stick, or in furrows made by tractors or horses/bullocks. The soil in holes dug by hand may be loosened using a fork prior to planting. The tops are planted with the corm section 15-20cm below ground level, and the new dalo corm grows upwards from the planted piece of corm. Soil is then firmly pressed against the planted sucker. Planting too deep can reduce the vigour of the plant, decreasing the quality of the dalo harvested.

Do not plant dalo directly into holes left from the harvest of the previous crop as nutrients can be depleted in the area around a plant, and there may also be a build-up of pests and disease in the root zone of the previous crop. It is best to always dig a new planting hole.

- Ministry of Agriculture field staff can assist farmers with advice about row spacing and planting density, and farmers should experiment further to determine the best spacing for their farm and the varieties that they use.
- It is important that the corm is planted at the right depth so that it grows healthily and develops a good shape.

Fertiliser use



All crops remove nutrients from the soil, and it is important that farmers have strategies to replace the nutrients used by the crops. Fertiliser application can improve dalo quality and yields, by improving growth and the resilience of dalo plants to disease. The use of fertiliser may also assist in ensuring that the dalo will meet the quality standards required for export. However, fertiliser can be expensive and needs to be used with care. There is increased interest in organic farming systems and the use of alternative fertilisers.

Traditionally dalo was grown using “slash and burn” practises, moving crop areas from one place to another to allow soil fertility to recover. The move to higher production farming to supply export markets has led to a shift towards more extensive mono-cropping systems. Year-on-year cropping of dalo has led to a decline in soil fertility in some areas, and has highlighted the need to balance production with sustainability.

The Ministry of Agriculture provides some general advice about fertiliser and manure applications for dalo farming, as well as the timing of fertiliser applications. Fertilising dalo plants can improve their health, producing a better quality crop. However, it is always recommended that soil analysis should be done before fertilizer applications to ensure that nutrient deficiencies are correctly addressed and the crop is not over fertilised.

Incorrect application of fertiliser can result in wasted money, with the excess fertiliser washing into waterways. This excess fertiliser damages the quality of drinking water in the streams, but also flows out to sea damaging Fiji’s reefs and impacting coastal fisheries. Timing of fertiliser applications should also be considered, as fertiliser applied to maturing dalo and plants that are too young is wasted. Poor timing of fertiliser can lead to quality issues because of irregular or peanut shaped corms.

Anecdotal evidence suggests that over fertilisation may also have an impact on dalo quality. In some areas large immature corms with poor texture have been received by exporters.

Further work needs to be done to understand if this is a result of over fertilisation.

Work has been done in Fiji on organic farming techniques and alternative farming practises to help improve soil nutrition in these areas, such as the use of green manures, long fallows and organic fertilisers. Work by the Ministry of Agriculture indicates that incorporating *Mucuna* beans into rotations or using it as a cover crop has benefits for crop productivity. Work on the development of organic practises is ongoing, and the Ministry of Agriculture is best placed to keep farmers up to date on the latest developments and recommendations regarding this.

- Year-on-year cropping of dalo depletes soil nutrients and this needs to be balanced with strategies to replace the soil nutrients used by a crop.
- Fertiliser needs to be applied in correct quantities and at the right time during a crops to avoid irregularly shaped corms. Soil testing can help understand what fertiliser might be needed.



Weeds, pest and disease management



Weeds, pests and diseases can reduce the health and productivity of dalo plants, reducing yield. Pests and diseases also cause damage to the dalo corm reducing its quality and can reduce the storage life of the harvested dalo. Pest and disease damage can also make dalo corms harder to clean.

Weeds, pests and diseases can have an effect on the productivity of dalo, effect the shape of the corm as well as cause rots and damage that decreases quality. Many weeds, pests and diseases are difficult for farmers to control and it is better to try and prevent damage rather than treat them once they have become established in the crop.

Over time it is important that farmers try to gain knowledge about what conditions increase or decrease the occurrence of pests and try to put in place strategies to reduce the impact of weeds, pests and diseases on their crops. Knowing what pests, diseases and weeds occur in the crop is the first step. The Ministry of Agriculture can provide some support in the identification of pests and diseases, as well as up to date advice on suitable measures to treat and prevent weeds, pests and diseases.

Exported dalo can be tested for chemical residues and contaminants. The presence of chemicals and contaminants can lead to export shipments being rejected. This damages Fiji's reputation as a source of clean and healthy produce in the international marketplace, and it has the potential to reduce demand for Fijian dalo and the prices offered in these markets for Fijian dalo.



Weed control

The young dalo crop must be kept weed free in the first 4 months. This is crucial to promote the growth of the plant and maintain quality requirements for export. Weeds compete with the dalo for moisture, nutrients and sunlight, making it difficult for young dalo plants to thrive. Weeds can be either controlled manually or with herbicides.

If herbicides are used it is important to always follow the instructions specified on the label, following the specified application rates and using protective clothing and equipment. Herbicide spray must not reach the dalo plants as it will affect the dalo plants growth and the quality of the corm. Always spray in still conditions and use a shield to prevent the spray from coming into contact with the dalo plant.

Mulches can be used to help prevent weed growth and Mucuna bean has proved to be useful in suppressing weeds in some areas.

- Dalo crops need to be kept free of weeds during the first four months of their growth.



Pests

Pests can often be found in small numbers in dalo crops, but healthy dalo crops are relatively resistant to many pests and do not often require significant pest control. However, pests can transmit diseases, particularly viruses, between plants allowing a disease to spread through the crop. These pests and the associated diseases make the dalo grow less vigorously and can decrease the size of corms harvested.

Pests, particularly dalo beetle, living in the soil can damage the corm allowing rots to affect the plant. Damage from soil borne pests decreases corm quality by making them susceptible to rots and customers do not like to buy the damaged corms when they are presented at markets. Nematodes and mites living in the soil do not normally cause problems for dalo crops, but they are an important pest in some of the export markets. Exporters are responsible for ensuring exported dalo is free of quarantine pests such as mites and nematodes.

It is important that pests are managed in accordance with the latest Ministry of Agriculture recommendations. If any type of pesticide is used it is important to always follow the instructions specified on the label, following the specified application rates and using protective clothing and equipment. Where pesticides specify particular withholding periods between spraying and when the crop can be harvested these must be followed. It is important that pesticides are not over used as this can cause the pests to become resistant to the chemicals, as well as killing beneficial insects that may feed on the pest insects.

- Crops should be inspected for pests, particularly dalo beetle, to ensure that they are not causing problems.
- The best approach to managing pests is to try to avoid outbreaks by rotating the location of crops, and ensuring the crop is not subject to nutrient or water stress which might make them susceptible to pests.

Whiteflies

These are small (1-1.5 mm long) moth-like insects with white wings, the immature whiteflies are small (1 mm long), oval shaped nymphs that live on the plant. These insects suck the sap of the plant, reducing the vigour of the plant. The adult flies can spread viruses. They may be controlled by appropriate insecticides, and a break or fallow of at least 2 months can help prevent an infestation in the following dalo crop.



Caterpillars

These include cutworms and hornworm, which feed on the leaves and stems of the dalo plant. They may be controlled by appropriate insecticides, and a break or fallow of at least 2 months can help prevent an infestation in the following dalo crop.



Aphids

Aphids grow up to 1.5 to 2mm long. The adults may or may not have wings and can be a variety of colours including greenish yellow, red-brown to almost black. Colonies may be found along leaf veins. Adults give birth to live young and do not produce eggs. Ants may also be present feeding on honeydew produced by the aphids. Aphids can spread diseases between plants.



Mealybugs

These are small insects covered in a white waxy or 'mealy' substance and suck sap from the plant. On dalo plants they can occur around the base of the plants and on the corm, and may not be seen until the dalo is harvested. Adult mealy bugs do not move and are often oval shaped and about 3-4mm long. Mealy bugs feed on sap, weakening the growth of the plant. A break or fallow period can help to prevent an infestation in the following dalo crop. Any dalo that is found with mealybug when harvested should be discarded.



Plant hoppers

These are small (5 mm long) triangular or wedge shaped insects which jump around on the plants. They feed on the underside of leaves, sucking sap from the plant. They can spread diseases between plants.



Pests on dalo important for export

Dalo beetle (*Papuana uninodis*)

These are shiny black beetles (25 mm x 12 mm), which feed on dalo corms by burrowing into them. The beetle and its larvae burrow into the corm and the resulting holes and wounds allow corm rots to occur which can result in significant crop losses. The damage from the insect decreases the attractiveness of the corm in the market. It is not possible to sell damaged corms in export markets, and even local markets do not tend to buy damaged corms.

They may be controlled by appropriate insecticides, but advice should be sought from the Ministry of Agriculture. The best control measure is removing or destroying the infested crops immediately after harvest and cultivating the soil to destroy surviving adults and larvae.

Dalo mite (*Rhizoglyphus minutus*) and nematodes

Mites are microscopic organisms that live in the soil and attach to the lower parts of the corm. Nematodes are microscopic worms that live in the soil, and some species can feed on the sap of the dalo.

Both mites and nematodes occur naturally in soils and they do not do any significant damage to the corm, and are generally not regarded as a pest by farmers. However, some export markets regard them as a pest which are subject to quarantine treatments. When exporting to these countries the exporters have to thoroughly clean dalo to remove all traces of mites and nematodes. For this reason it is important that farmers try to produce healthy dalo that is even in its shape and easy to clean.



Diseases

Dalo is susceptible to diseases in the upper parts of the plant and in its roots. Diseases should be managed in accordance with the latest Ministry of Agriculture recommendations and Ministry of Agriculture staff can assist with the identification of diseases.

- Crops should be regularly inspected for diseases along with pests that might spread disease.
- Parts of diseased plants should not be used for planting material. Plants with signs of virus should be removed from a crop to prevent spread of the virus.

Viruses

There are a number of viruses that can cause damage to the leaves and petioles of dalo plants. Viruses cause patterns of various colours, shapes and sizes on the leaves and petioles, and this damage may reduce corm yield. Viruses are spread through the crop by insects (such as whiteflies, aphids and plant hoppers). If damage is seen in the crop then plants that show virus symptoms should be removed and destroyed, and once the crop has been harvested the tops of the dalo crop should be destroyed by burying them to reduce virus transmission within the crop or to neighbouring crops. It is very important that tops which show any signs of virus must not be used or sold as planting material.



Primary Rots

Primary rots are caused by soil borne fungi that infects dalo at soil level whilst the dalo is growing in the field. They can cause the corms and roots to rot and leaves to wilt, and may cause problems in wetland dalo. Primary rots cause significant damage to the quality of the dalo, and any rotten corms should be discarded at harvest. Packing dalo corms with rots amongst harvested dalo is a very bad practice as the rots can spread to surrounding healthy dalo corms. It can be difficult to manage primary rots, however minimising the amount of excess water in fields by digging and maintaining drains after planting may help to reduce the problem.

Secondary Rots

Secondary rots occur when there has been damage to the dalo corm. Examples of damage that might lead to secondary rots include damage from dalo beetle, damage from removing suckers from dalo, damage from harvesting tools, damage from bruising during harvest and transport. Rough handling of dalo during harvest can cause significant problems for exporters, leading to a lot of wasted dalo.



Leaf spots

There are a number of different fungal disease that can cause leaf spots in dalo. Spots from fungal disease can be circular or irregular with dark, orange or yellow coloured centres, and there can be yellowing around the margins of the spots. In some cases the centres of these holes can white or grey as they age and fall out, causing 'shot holes'. Spots can range in size from 2-5mm in diameter up to 15-20mm in diameter, and as the disease develop the spots can join up, leaving the leaves with a tattered appearance. Leaf spot diseases are generally not of great importance, and specific controls are generally not used. However, it is good practise to remove and destroy infected leaves by burning, as this will reduce the spread of the disease through the crop. It is important that dalo leaves harvested for sale are free of any leaf spots.



Taro leaf blight (*Phytophthora colocasiae*)

Fiji is currently free of taro leaf blight, but all Fijians should remain vigilant about this potentially catastrophic disease. Taro leaf blight was responsible for the devastating loss of dalo production in Samoa in 1993 and it has taken many years for their industry to recover. Some export markets will only import fresh dalo from countries like Fiji which are declared free of taro leaf blight.

It is very important that Fiji remains taro leaf blight free, any possible signs of the disease should be reported to the Ministry of Agriculture or Biosecurity Authority of Fiji immediately.

Taro leaf blight symptoms mainly occurs on the leaves of the dalo plant. Initially small brown spots occur on the leaves. These get bigger and turn into large brown lesions which may be yellow around the edges. Leaves die within the space of a few weeks and the dalo plants are left with few healthy leaves. This has an impact on the health of the dalo corm and there is a significant drop in yield. The disease can also cause rots in the corms once harvested. The disease is spread to adjacent plants and crops by rain and wind, and can also be spread through infected planting material.





Keeping farm records

Keeping farm records to understand how changes to your farm practises influences quality and yields can help to improve the quality of your crops over time. Records provide a way of learning how to produce the best yields and quality dalo from your farm.

Keeping farm records helps to

- 1) understand that value of dalo crops and how it changes from year to year and at different times of the year,
- 2) improve consistency of production and quality,
- 3) record how new practises and varieties might influence production and dalo quality, and
- 3) remember and schedule when to do certain activities such as apply fertiliser and check for weeds, pests and disease.

Maintaining records is particularly important to learn and improve the control of pests and diseases and keep track of withholding periods for pesticides. Without records to refer to it can be difficult to recall what happened in previous years and it can be hard to change practises. Record keeping is an important way of continually improving a farm business and improving the quality of dalo produced.

Keeping farm records is a useful way to help develop skills in staggering plantings (phase planting) and harvesting. At peak harvest times

there is often an oversupply of dalo in the market leading to poor prices. Keeping records and experimenting with planting times can help farmers to target their harvest at times when prices are higher and avoid oversupplying the market.

Understanding and managing income from farms also allows farmers to understand the potential costs and returns from investing in machinery or measures to improve production. The Ministry of Agriculture's "Crop Farmer's Guide" provides space for farmers to make records of their annual plantings as well as a useful guide to crop husbandry.

- Keeping farm records are an important part of managing a farm and improving quality and productivity from year to year.



Managing farm workers

Farm workers are an important link in ensuring the quality of a crop, and can influence the quality of the crop through their work in planting and maintaining the crop and during harvest. It is important to clearly explain to workers what needs to be done to ensure the crop is productive and of high quality.

Examples of activities where it is useful to give workers supervision or direction include:

- **Farm preparation.** Poor land preparation can lead to poor production and quality in the crop. Workers need to clearly understand what is expected.
- **Checking for pests and diseases.** Workers need to be aware what pests and diseases might be in the dalo patch so that they can keep an eye out for them, and they need to know to tell the farmer there is a problem when they see it.
- **Spraying chemicals.** Workers need to make sure they mix chemicals correctly, they spray the correct areas and they use protective equipment.
- **Do not harvest suckers before the crop is ready for harvest.** Taking suckers from immature dalo plants causes damage to the corm and rots can get into the corm from the soil. This reduces yield and the quality of the dalo corm.

- **Handling.** It is important that workers know to treat harvested dalo corms with care, in particular not throwing or dropping the corms which will cause bruising and secondary rots, reducing dalo quality.
- **Quality standards.** Workers need to know what quality dalo looks like so that poor quality dalo can be sorted before it is delivered to the middleman/exporter.



Managing risks from cyclones

Dalo is particularly susceptible to damage from cyclones. Young plants may recover, but damage in older plants can result in a decrease in the quality and yield. Dalo crops close to maturity should be harvested soon after cyclones to prevent further deterioration in quality from rots.

Care needs to be taken to only use good quality disease free planting material to re-establish farms after cyclones. Unfortunately it is easy for pests, diseases and weeds to be easily spread in planting material when it is moved from one area to another after a cyclone.

It can be difficult to protect dalo crops from cyclone damage. Measures that can reduce damage from flooding and storm surges can help to reduce damage from cyclones. Avoiding planting and building in areas that have been damaged by cyclones in the past may also be a useful strategy. Establishing a few plantings in different locations may also be a way of spreading the risk of crop damage for some farmers, and also provide nursery material to re-establish farms damaged in the cyclone.



Climate change

Finding ways to reduce the impact of extreme weather events is an important step in preparing for the long term effects of climate change. It is important that farmers look to learn from each other but also try out their own ideas for reducing losses from extreme weather events. A number of expected climate change impacts are described below, along with possible strategies to help adapt to the changes.

Flooding and extreme rainfall

It is expected that rainfall will be more variable, leading to more droughts but also heavier rainfall during storms. The heavier rainfall could lead to local flooding and erosion, which may damage farmland and lead to crop losses. There is the potential for dalo crops to be washed away in heavy rain, but also for damage from diseases and pests in crops that get flooded.

The sorts of practises that can help farmers to prepare for these sorts of events includes avoiding planting on very steep slopes and areas where damage from rainfall is known to occur, making sure that fields are properly drained, maintaining drains by keeping them free of debris and using dalo varieties that are tolerant to wet soils in areas that are prone to flooding.

King tides and storm surges

Increases in sea level will increase the frequency of flooding from king tides and storm surges in low lying areas. Heavier rainfall is also likely to contribute to these local flooding events. Increased numbers of these flood events will lead to greater crop losses where coastal land is currently susceptible to inundation, and some low lying areas adjacent the coast may become too salty to plant dalo.

Planting dalo in mounds and preparing good drainage may reduce the impact from flooding. Longer term solutions may include moving planting areas to higher ground, using dalo varieties that are more resistant to salty conditions or finding alternative crops.

Drought, increased temperature and variable rainfall

Increases in temperature and the potential for longer periods without rain may cause dalo plants to suffer from water stress. Drought and water stress can cause the loss of plants or reduce the health and yields of affected plants. Drought affected plants may also be more prone to attack from pests and disease. In some locations where dalo is being grown close to a water source, or there are tanks or ponds available, it may be feasible to irrigate the dalo during dry periods. It may also be better to avoid planting on areas which have a high slope as they the soil there may not hold as much moisture as flatter areas.



**Good harvest
and post-
harvest
handling
practises on
farm**

Correct harvesting is critical to good quality dalo. The dalo needs to be harvested when it is properly mature. Harvesting and handling the corms after harvest needs to be done with care to avoid damaging the dalo and maintain its quality. Dropping or throwing dalo, over packing and mishandling sacks of dalo and poor storage of dalo are all damaging practises that must be avoided. It is also important that poor quality dalo is discarded at harvest, as it can be the source of secondary rots in the harvested dalo.



Timing of harvest

Maturation varies between cultivars, with hybrid cultivars often ready for harvest earlier than the local or traditional varieties. The approximate harvest times of the different varieties is included in the variety descriptions earlier in this manual. An indication of maturity is when the dalo plants look reduced in sizes and leaves turning yellow and withering. This is called senescence or “mago” in Fijian. At this point the dalo corms will be starting to taper (get smaller) towards their top, the amount of roots it has (its root mass) will have reduced and the water content of the corm will be relatively low.

Farmers generally rely on experience to determine when to harvest dalo and what dalo is good quality. Healthy plants should be selected for harvest, with farmers looking at the top of the corm/base of the leaves as well as the plant’s resistance to being pulled as an indication of size and quality. A mature dalo plant has little resistance to being uprooted.

Dalo corms harvested before maturity are of poor quality. There is a higher risk of damage to the dalo corm when harvesting because of the larger root mass, and a greater risk of spoilage because of the higher water content. The dalo taste and texture can also differ from a mature dalo. Dalo that has been left too long also has poorer taste and texture, and older corms may be smaller in size than properly matured corms. Dalo with any signs of rot, including damage at the base of the leaves (petioles), should not be harvested or if harvested they should be discarded.

If the dalo is being harvested for an exporter/middleman then it is important to coordinate with them and confirm that they are prepared to accept the dalo before starting harvest.

- Dalo should only be harvested when it is fully mature, and only healthy plants should be selected for harvest.

Harvesting dalo crops

Harvesting should occur in the morning or late afternoon when temperatures are cooler. It is best to harvest in dry conditions as this can help to reduce the incidence of rots. Harvesting in cool conditions helps to maintain the quality of the dalo. If harvesting dalo in wetland areas it is important that excess water in the fields is drained before harvest to reduce the possibility of secondary rots occurring.

During harvest it is also important to ensure that the dalo suckers are not damaged. This helps to ensure that the planting material is healthy and will grow a good crop. It is also important to use clean tools where possible to prevent the spread of disease between fields.

Improper harvesting is a major cause of damage to the dalo corms and this has a big impact on quality. Much of the damage that is done by dropping or throwing dalo which causes bruising and may lead to secondary rots. This damage is often not seen by the farmer and workers, as it may take a three or four days to develop. To avoid this damage farmers should work out a system for transporting dalo to collection points in the field which minimises dropping or throwing the dalo.

For example, the worker harvesting the dalo should leave it on the ground where it has been pulled, and a second worker should pick up the harvested dalo. The harvested dalo should then be moved to the collection point using wheelbarrows, trolleys or sleds to prevent damage. At no point should the dalo be dropped or thrown. Workers need to be clearly told how they should harvest the dalo and given clear instructions not to drop or throw dalo corms. Where possible harvesting should be supervised to ensure workers follow these instructions. The harvested crop should be moved to a dry shaded place in the field so it can be sorted and stored for collection.

Clean tools and knives should be used during harvest. Tools should always be cleaned after use and stored in a dry place (not put in the ground) when not used to prevent rust and help them to stay clean. Rusty tools and knives can spread disease in harvested plants as well as spread diseases across a farm.

- Care should be taken during harvesting and handling to minimise damage to corms. Never throw or drop dalo.
- Corms should be harvested in the cooler parts of the day.
- Harvested corms should be moved with care to the collection point, and at no point should dalo be dropped or thrown.



Cleaning, sorting and preparation in the field

After harvesting, farmers should check the harvested dalo and discard any corms that are damaged, diseased or infested with pests. It is important that farmers are aware of the quality standards expected by the middleman/exporter and make sure that the harvested dalo meets these standards.

Dalo for local markets

Dalo destined for local markets should also be checked and corms that are damaged, diseased or infested with pests should be discarded. This is because it is important to minimise the spread of pests and diseases to other locations. Corms are usually be tied into bundles or grouped into similar sizes. Avoid making bundles of dalo too heavy and difficult to handle, as this can result in rough handling and damage to the dalo. Dalo with the tops removed may dry out, reducing the quality and storage life of the dalo which may make it less appealing to customers.

For dalo intended for export markets the tops should be cut to approximately 5 cm in length once harvested in the field. Cutting the tops shorter than 5 cm may cause the corms to dry out during transport and handling, reducing the quality of the dalo.

Dalo being sold for export should have excess soil, older petioles and root material gently removed from the dalo corm. It is common to leave some roots attached to the corms to provide protection during transport and handling. Middlemen and exporters should give farmers clear instructions about how the dalo should be cleaned prior to the dalo being collected, as well as the quality and size standards they are expecting.

Middlemen and exporters will also give farmers instructions about packing the dalo for collection. Generally it is suggested that where possible the dalo is not packed until the transport has arrived. This gives the middleman/exporter the opportunity to inspect the crop whilst it is being packed and they can discuss the quality of the dalo with the farmer, and check that the

dalo does not include too much soil and other debris. Packing dalo and leaving it in bags before collection may result in the dalo staying wet, which can encourage rots.

When packing the dalo into polypropylene bags in is important that care is taken to ensure that the corms are not damaged or overpacked in the sacks. Do not force the dalo corms into overpacked bags. When packed it should be possible for each sack to be carried comfortably by a single person. Mishandling during loading and unloading of vehicles due to overpacked sacks that are difficult to carry can cause significant damage to the dalo.

Care must be taken when handling dalo. Losses from bruising, rots and undersized dalo received at packhouses after transport from farms have been reported to be as high as 30 per cent. It may also take 4 to 5 days for any bruising that occurred during harvest and handling to appear, which may mean some damage is only visible after the dalo has been shipped to the export market.

It is good practise to label the packed dalo with the name of the farmer, the farm location, the variety and date of packing for delivery to the middleman/exporter. This can help middlemen and exporters to trace back the dalo to where it was grown if there were quality issues that need to be addressed or if they were seeking more dalo of the same quality.

In ideal circumstances the loose dalo would be put into large plastic field bins or smaller plastic or wooden crates. Plastic bins and crates protect the dalo from damage during transport, with some estimates indicating damage can be reduced to one third of that currently experienced. However, road access to dalo fields can be limited making it more labour intensive to use crates than bags, depending on the size of crate they might not hold as much dalo as bags and the outlay to purchase crates is higher than bags. Good road access is particularly important if field bins and crates are to be used more regularly in the future, along with high prices for dalo which can help to justify the outlay of purchasing the crates.

Storing dalo prior to collection

- Excess soil and plant material should be removed from corms at the time of harvest.
- Corms that are physically damaged or have symptoms of rot or pest infestation should be discarded to prevent the spread of pests and diseases and improve the shelf life of the crop.
- Headsets should be trimmed to a length of approximately 5 cm at the time of harvest.
- Never throw or drop dalo.
- Middlemen and exporters should clearly describe what quality and size standards they require prior to collecting the dalo.

Dalo should be initially cleaned in the field before being collected.



It is important that the harvested dalo is not stored for long so that it can get to the market as quickly as possible to maintain its quality.

Once harvested the dalo should be placed in a dry cool, shady location that is protected from the elements to prevent it from excessive drying or getting damaged by bad weather. Do not store wet dalo under tarpaulins, as this can promote rots and further damage from pests. It can be useful to build a simple lean-to or shed structure to keep the crop covered. It is also useful if the ground is covered to prevent pests, insects and weed seeds from getting into the harvested crop. It is preferable that dalo is stored off the ground to reduce the risk of pests contaminating the load, to ensure the dalo remains clean and free of excess dirt and to allow air circulate around the dalo which can help prevent rots. For example, a low platform made up of wooden pallets could be used.

Do not store the crop under structures or in locations where fuel, chemicals or fertiliser has been stored or mixed. If the dalo is stored in packed in bags waiting collection the bags should be stacked in such a way as to prevent damage from bruising and crushing.

Farmers should arrange the harvest so that the time the dalo is left stored in the field is minimised. It is important for middlemen and exporters that the dalo is collected at the time that has been arranged, because leaving the dalo for extended periods will reduce its quality. Delays may also cause problems meeting deadlines for export shipments.

- Corms should be stored in a dry, shady location, and in a manner that will prevent contamination with pests, insects, weed seeds or other things that might damage the quality of the dalo.

Avoiding over harvesting and over supplying

Exporters and middlemen cannot be expected to take more than the amount of dalo than had been agreed upon. Taking extra dalo can overload trucks, which is likely to damage the dalo being transported but it will also damage the roads. It is illegal and unsafe to operate overloaded trucks.

Middlemen and exporters also have limited processing and cold storage capacity. They only buy as much as they can store and sell for export. During the main dalo harvest period exporters are not able to sell all the dalo available to export markets, and there is often an oversupply in local markets. Farmers should consider how they can develop a staggered planting schedule to help spread their harvest period, and this can also help to improve the prices they receive at market.

It is important that middlemen and exporters clearly explain how much dalo they are looking to purchase and their expectations on quality and size standards prior to collecting and purchasing the crop. Poor communication about quality, size standards and the volume of dalo required can result farmers feeling frustration and disappointment.





Grading for quality

Harvested dalo is graded at the farm before it goes to market or to middlemen or exporters. Middlemen and exporters will further grade the dalo to make sure it meets the quality requirements of their customers. Dalo is checked to make sure that it meets requirements for size and shape, it is the correct variety, it is free from injuries and it is free from pests and diseases.

Middlemen and exporters should clearly explain the quality and size requirements for dalo they are looking to purchase prior to coming to collect or accepting the delivery of the harvested crop. It may not be practical to require harvested dalo to be completely free of quality faults, so measures such as “no more than 10 to 15 corms in 100 with injuries or irregular shapes” may be useful.

Variety

Exporters generally want dalo varieties that are attractive to their customers and that have a long shelf life.

Exporters may specify particular varieties. The varieties listed in this manual are the varieties that are commonly grown. Not all are suitable for export as fresh dalo.

Size

Corms of dalo sold for export as fresh dalo must usually weigh more than 300 grams. Generally A-grade dalo corms would weigh between 1 and 2.5kg, although this varies between exporters.

Corms less than 1kg or more than 2.5kg are regarded as B-grade and are less marketable.

Shape

Corms should be an even shape, without distortions and not “dumbbell” or “peanut” shapes.

Distortions and irregular shapes make the dalo more difficult to clean and remove all the soil. This can create problems when they are inspected for biosecurity compliance. Irregular shaped dalo is also less attractive to customers at markets. Distorted shapes can result from dry periods during the growing season or uneven fertiliser application throughout the growing season.



Free from holes, injuries and rots

Dalo should not have any fresh injuries, as these may be where rots might develop in the dalo corms. Press on the site of any scars with a finger to check that it is not soft from rots.

There are a number of different types of injuries that might occur, scars from where suckers were attached to the corm, cuts from farm implements and damage from pests (including dalo beetle, but also feeding by other animals such as slugs, rats and crabs).



Free from signs of bruising and mishandling

Dalo should never be thrown or dropped. Bruising and mishandling can result in rots and injuries that are not easily visible, but may lead to spoilage during transport and storage.

Broken skin is one of the few visible sign of bruising injury. It may take 4 to 5 days for any bruising that occurred during harvest and handling to appear, which may mean some damage may only become visible after the dalo has been processed and shipped to the export market.



Free from pests, insects and contaminants

There should be no visible pests on the dalo corms. The dalo corms should also be free of weed seeds and any other animals.

It is important that there are no pests such as dalo beetle or mealybugs on the harvested dalo. It is also important that any other insect or animal is brushed off the dalo before it is packed for transport. This helps to avoid insects and animals at the exporter's facility, which can in turn cause biosecurity problems in export consignments.





Cleaning and transporting dalo to local markets

Dalo that is handled with care and arrives at market in good condition will be more attractive to customers and can achieve higher prices. Dalo in good condition will also last longer, which is an advantage for stall holders selling the dalo and for customers.

The vehicles used to transport the dalo should be clean. Packed dalo should be loaded onto the transport vehicle gently to minimise the risk of damage to the corms, and the dalo stacked in a way that will reduce the risk of damage (crushing, for example) to the corms as they are transported to market. Nothing should be placed on the top of the stacked dalo that will damage to the corms. Ideally the corms should be placed on top of sacks or other material that will cushion them from damage, and prevent damage from hot surfaces.

Depending on the distance and conditions it can be good practise to cover the dalo bundles during transport to protect them from the elements and minimise contamination by dust, debris and insects. A light-coloured covering should be used to minimise heat absorption in the load. During transport, the smoothest transport route possible should be chosen to reduce the risk of dalo being damaged in transit. It important that the delivered dalo is unpacked carefully from the delivery vehicle to ensure it is not bruised or otherwise damaged.

Some dalo can be transported long distances from farms to markets using boats, busses, carriers, trucks and taxis. Long journeys to market mean that the dalo is handled many times as it is moved between vehicles. It is important that everyone in this chain takes care of the dalo to ensure it arrives at market in good condition. Dalo being sold at the market or roadside should be placed in a shady location that is protected from the elements to prevent it from drying out or getting damaged by bad weather.

- Corms should be handled gently during loading and unloading to minimise physical damage to the corms. Bags of dalo should always be placed on the ground, never be thrown or dropped.
- Dalo that is damaged, diseased or infested with pests should be discarded to avoid the spread of pests and disease, and to improve the shelf life of the dalo.
- Load and stack the dalo in transport vehicles in a way that will reduce the risk of damage (crushing, for example) to the corms.
- Corms should be covered during transport to prevent damage and contamination. It is recommended that a light-coloured covering is used to minimise heat absorption in the load.
- During transport the smoothest route possible should be chosen to lessen the risk of physical damage to corms during transit.
- When the dalo is put on display for sale it should be in a shady location where it is protected from the elements.





**Transport
from farms to
middlemen
or exporters
and
processors**

Transport can damage dalo, reducing quality. Care needs to be taken to reduce the potential for damage to occur wherever possible.

It is not uncommon for a middleman to be a part of the dalo export value chain, particularly on islands outside of Viti Levu where many exporters are based. The middleman essentially acts an intermediary between the grower and exporter. They can be involved in the transport of dalo and can perform an intermediate grading function. Farmers may deliver dalo to the middleman's premises, or alternatively, middlemen may collect harvested dalo from the farmers' collection points and transport the corms to their own premises.

Trucks and other vehicles transporting dalo should be clean and fit for purpose. Trucks and vehicles can be used to transport a range of goods, including fertilizers, chemicals and livestock, so it is important that the vehicle is cleaned before use. Truck trays should be in good condition as sharp edges and damaged surfaces could injure the dalo, and are more difficult to clean. Ideally trucks should be parked in shade if they need to wait before picking up harvested dalo to prevent the tray from heating up which might cause damage to the dalo. The truck tray can also be lined with cardboard or leaves to help reduce heat and physical damage from the truck. Trucks should be loaded towards the front of the truck where possible, as this area is less prone to excessive in-transit damage. It is important that farm chemicals, animals and farm equipment are not transported with loads of dalo as this creates a food safety risk.

Packaged dalo should be loaded onto the transport vehicle gently to minimise the risk of damage to the corms. Where polypropylene sacks are used they should be stacked in a manner that will reduce the risk of damage (crushing, for example) to the corms. Ideally fresh polypropylene sacks should be used, as re-using sacks (particularly ones that have been used for dalo or other root crops) can spread diseases between farms. It is important to avoid using sacks that have been used to carry chemicals (for example fertilisers) as this creates a food safety risk. Nothing should be placed on the top

of the stacked dalo that will increase the risk of damage to the corms. It is recommended that the tray and sides of the transport vehicle be covered with rubber or another cushioning material to lessen the risk of damage to corms due to vibration and jarring of the vehicle.

Depending on the distance and environmental conditions through which the corms must be transported it may be necessary to cover the load for transport to protect it from the elements and minimise contamination by dust, debris and insects. A light-coloured covering should be used to minimise heat absorption in the load. During transport, the smoothest transport route possible should be chosen to reduce the risk of dalo being damaged in transit.

- Corms should be handled gently during loading and unloading to minimise physical damage to the corms. Load towards the front of the truck if possible, as this area is less prone to excessive in-transit damage. Prior to loading trucks should be parked in the shade where possible to avoid heat damage to the dalo.
- Where polypropylene sacks are used they should be loaded and stacked in a manner that will reduce the risk of damage (crushing, for example) to the corms. Wooden or plastic crates and field bins can be a better option as they may be stacked to reduce crush damage to the dalo. Dalo should not be loaded as loose corms in the back of vehicles.
- If sacks are re-used they should be clean. Avoid using sacks that have been used to contain chemicals (for example fertiliser) as this creates a food safety hazard. There is also a risk that sacks that have been used to carry dalo and other root crops may also spread disease between farms.
- Corms should be covered during transport to prevent contamination with weed seeds and insects. It is recommended that a light-coloured covering is used to minimise heat absorption in the load. It is always preferable to use a truck with a canopy.
- During transport the smoothest route possible should be chosen to lessen the risk of physical damage to corms.



Sorting and processing by middlemen

Middlemen have a role in grading dalo to help ensure that shipments are of consistent size as well as checking dalo quality. It is important that this handling does not result in damage to the dalo and a decline in quality prior to the dalo being transported to the processor or exporter. Upon receipt, packages should be gently removed from the transport vehicle and corms removed from their packaging in a way that will ensure they are not bruised or otherwise damaged. Corms should be unpacked onto a clean, smooth surface for sorting and grading. Export dalo should be segregated from non-export product.

Corms are sorted and graded to remove any that do not meet export quality or biosecurity requirements. Any corms that are deformed, damaged, under- or over-sized, infested or have symptoms of rot are removed from the export pathway at this point.

Following sorting and grading corms are repackaged for transport to the exporter's packhouse. Plastic bins are ideal as they lessen the risk of damage to the corms. However, given the relatively high cost of plastic bins and that lower volumes of corms can be packed in a given space, the economics of the packaging material used will need to be considered. Polypropylene sacks are often used as they are relatively inexpensive and can accommodate more corms.

Packaging material should be clean to lessen the risk of contaminating the graded corms. Care must be exercised to ensure corms are not damaged during repackaging. Particular emphasis should be placed on ensuring polypropylene sacks are not over-packed which may increase the likelihood of damage to the corms; overpacked sacks are heavy and difficult to handle and result in rough handling. It is recommended that sacks are packed to a maximum weight of 30 kg.

Where it is necessary to store product prior to transport to the exporter's packhouse corms should be held in a cool, well-ventilated location that is protected from the elements. The product should be secured to prevent contamination from insects, weed seeds and debris.

- Corms should be handled gently during unpacking, grading and repacking to minimise physical damage.
- Export dalo corms should be segregated from non-export corms at all times.
- Any corms that are deformed, damaged, under- or over-sized, infested or have symptoms of rot are removed from the export pathway during grading.
- Corms should be repacked into clean packaging material to minimise the risk of contaminating the graded corms.
- Where polypropylene sacks are used, they should be packed to a maximum weight of 30 kg to enable careful handling of the sacks.
- Graded and repackaged corms should be held in a cool, well-ventilated location that is protected from the elements and free from contaminants.



Transport from middlemen to exporter packhouses and processors



Transport can damage dalo, reducing quality. Care needs to be taken to reduce the potential for damage to occur wherever possible.

Transport vehicles should be clean and fit for purpose. Packaged dalo should be loaded onto the transport vehicle gently to minimise the risk of damage to the corms. Where polypropylene sacks are used they should be stacked in a manner that reduces the risk of damage (crushing, for example) to the corms. Nothing should be placed on the top of the stacked dalo that will increase the risk of damage to the corms. It is recommended that interior surfaces of the transport vehicle payload area be covered with rubber or another cushioning material to lessen the risk of damage to corms due to vibration and jarring of the vehicle.

Depending on the distance and environmental conditions through which the corms must be transported it may be necessary to cover the load for transport to protect it from the elements and minimise contamination by dust, debris and insects. A light-coloured covering should be used to minimise heat absorption in the load. During transport, the smoothest transport route possible should be chosen to reduce the risk of dalo being damaged.

Care needs to be taken with dalo transported via inter-island shipping as there can be further handling and potential for damage during these trips.

- Corms should be handled gently during loading and unloading to minimise physical damage to the corms.
- The tray and sides of transport vehicles should be covered with rubber or another cushioning material to lessen the risk of damage to corms due to vibration and jarring of the vehicle.
- Where polypropylene sacks are used they should be loaded and stacked in a manner that will reduce the risk of damage (crushing, for example) to the corms.
- Corms should be covered during transport to prevent contamination by dust, debris and insects. It is recommended that a light-coloured covering is used to minimise heat absorption in the load.

- During transport the smoothest route possible should be chosen to lessen the risk of physical damage to corms.





Processing in packhouses for export

Processing should ensure that the dalo is cleaned and presented so that it is attractive to customers in export markets and that the dalo meets to biosecurity requirements of those markets. Care needs to be taken to avoid damaging the dalo, but also that the cleaned and graded dalo does not become contaminated. Carefully processed dalo can avoid costly, time-consuming and potentially damaging biosecurity treatments in export markets.

Processing in packhouses prior to export serves to:

- Grade the dalo so that the product is of uniform quality
- Ensure that the dalo is clean, well presented and attractive to customers
- Ensure the dalo meets the requirements of the importer/customer
- Ensure that the dalo meets biosecurity requirements of the importing country

Different exporters have different standards and sell to different markets which have different requirements. In the competitive export market it is important that Fijian dalo maintains and develops its reputation for quality so that it can continue to compete in the market.

Currently both the New Zealand and Australian markets have stringent biosecurity requirements that can usually be met by exporters, avoiding fumigation upon arrival. Fumigation is used by Australia and New Zealand to destroy microorganisms, particularly mites and nematodes, when they are found in shipments of exported dalo. Fumigating dalo shipments is costly, substantially reduces the quality of the dalo and decreases the shelf life if the product. Fijian exporters should work to ensure their exported dalo meets the biosecurity requirements of these countries without the need for fumigation.

Each corm is handled a number of times as it is processed and packed. This creates the possibility that the corms will be mishandled, including being dropped or thrown. Packhouse staff should be instructed to handle the dalo with care to prevent injury to the corms.

Damage from poor handling might take 4 to 5 days to appear, so it is possible that any bruising or internal damage that occurred at harvest or during any subsequent transport and handling may not be visible after the dalo has been exported. Implementing systems that can help trace back exported dalo through the supply chain to individual farms can assist exporters to identify where poor handling practises have occurred and reduce the possibility of future losses.

It is important that packhouse staff are confident in their understanding of the exporter's standards so that dalo can be inspected and that substandard dalo is removed from the processing line whenever it is seen.

It is important that packhouses are built and maintained to a high standard to avoid contamination of the exported product, and to ensure that packhouses are thoroughly cleaned between shipments. Packhouse workers should also be expected to follow personal hygiene rules.



Receival

Upon receival, packages should be gently removed from the transport vehicle and corms removed from their packaging in a manner that ensures they are not bruised or otherwise damaged. Export dalo must be segregated from non-export product during packhouse operations. The level of processing at the packhouse will be dependent on the destination market.

- Corms should be handled gently during unloading and unpacking to minimise physical damage to the corms.
- Export dalo corms must be segregated from non-export corms at all times.



Trimming corms

Roots are removed by hand pulling and trimmed using a knife. Any suckers should be cut off and trimmed. There should be few if any remaining roots on the dalo and dalo corms are often scraped to remove these. The corms need to be trimmed in accordance with export market requirements.

To meet Australian import requirements the tops of the dalo (including petiole bases) need to be removed, along with any lateral buds, shoots and corms. Extraneous root material is also removed, usually by peeling.



To meet New Zealand import requirements it is general practise to trim the tops of the dalo with a clean, straight cut to a length of 5 cm. Extraneous root material is then removed from the corm, often leaving some of the skin on the surface of the dalo.



The degree of cleaning and aggressiveness of trimming can vary depending on the market for the dalo and the standards set by the exporter. Some export markets prefer a natural appearance to the dalo where the brown and flaky skin is retained. Achieving this appearance whilst meeting biosecurity standards may present difficulties.



During trimming packhouse staff must visually examine corms and remove any corms from the export pathway that do not meet export quality or biosecurity requirements. Particular attention should be given to removing misshapen or physically damaged corms, as well as corms displaying disease symptoms. Immature and under- or over-sized corms should also be removed when seen. Corms should be free from any softness and decay associated with rots and bruising.

All waste from the trimmings should be removed immediately and either buried or taken away from the vicinity of the packhouse. This is important to ensure that there is not a build-up of pests or material that might contaminate cleaned dalo in and around the packhouse.

Washing of corms

Dalo corms must be washed in clean water to remove all soil, insects, root fiber, and other extraneous material.

It may be necessary to use pressurised water or soft brushes to ensure all matter is removed from the corms. The method of washing used varies between backhouses. Dalo is washed by hand using a high pressured hose or with washing machines. When washing by hand the corms are either washed individually or by placing the corms in a single layer and spraying them with a hose and nozzle.

During washing packhouse staff must visually examine corms and remove any corms from the export pathway that do not meet export quality or biosecurity requirements. Particular attention should be given to physically damaged corms (if there are deep cuts, holes or insect damage for example) and any sign of disease symptoms such as softness and decay associated with rots and bruising.

Packhouse staff need to make sure that the dalo is properly cleaned with no soil remaining on the corms once it has been washed.



Some trials have been undertaken examining the effectiveness of using a 0.05% sodium hypochlorite dip to improve the shelf life of “top and tailed” dalo destined for fresh export to Australia and New Zealand. The study indicated that dipping in sodium hypochlorite did not prevent of fungal growth (rot) on the dalo.

Trials have also been undertaken on use of hot water dips to control mites and nematodes on dalo for fresh export. Dipping dalo for 12 minutes at a water temperature of 50°C was shown to kill all parasitic nematodes and mites, however some saprophytic nematodes remained alive. After 12 minutes the surfaces of the corms had a temperature of 35.8°C, the corm surface temperature had to reach 40.6°C before all nematodes were killed. Dalo dipped in water at 50°C for 12 minutes also showed minimal corm rot after 21 days storage, suggesting that hot water dips may improve shelf life. These study indicated that whilst effective at controlling mites and nematodes the costs of installing and operating a commercial sized hot water dip was unlikely to be viable. Other forms of heat treatment, such as high temperature forced air or vapour treatment may be more effective measures but further research and development is needed including on the costs involved.

All waste from washing should be removed immediately and either buried or taken away from the vicinity of the pack house. This is important to ensure that there is not a build-up of pests or material that might contaminate cleaned dalo in and around the pack house.

- Corms must be washed in clean water to remove all soil, insects, and extraneous plant material. Use pressurised water or soft brushes as necessary.
- Corms must be visually inspected during washing and any corms that do not meet export quality or quarantine requirements must be removed from the pathway.

Grading and inspection

During grading corms should be inspected for quality. Any corms with soil, physical damage (such as cuts) and roots remaining should be removed. There must be no signs of softness that might indicate rots or bruising. The corms should be an even round or oval shape with no deformities.

Dalo corms are to be sorted during cleaning based on weight/size and variety. Different customers have different preferences on dalo corm texture and the exporter must know this to meet their market requirements. The same varieties and sizes should be packed together, as mixing of varieties and sizes can lower selling prices.

Corms are often graded as either A grade or B grade depending on size. A grade corms generally described as weighing from 1 to 2.5kg. B grade corms are usually smaller or larger than this. The seller must be aware of their market preferences and then grade and pack corms according to sizes and varieties.



Processing for freezing or cooking

Freezing dalo for export offers some advantages for exporters and consumers. For exporters it can prolong the shelf-life of the dalo, and it is easier for the frozen dalo to meet biosecurity requirements in export markets. For consumers frozen processed dalo can offer a more convenient alternative to fresh dalo, and good quality frozen dalo can have a taste and texture similar to fresh dalo once cooked.

It is possible for dalo that does not meet quality requirements for export as fresh product to be processed into frozen product. However, it is important to remember that quality frozen dalo still requires quality fresh dalo, the taro needs to be a good texture and flavour when it is frozen. The dalo also needs to be clean and free of rots and other microorganisms, as freezing stops the growth of these microorganisms but may not destroy them.

It is possible that some varieties not currently exported as fresh dalo because of poor shelf life, small size or other characteristics, may be more attractive when processed and sold as frozen dalo.

The process for producing frozen dalo is outlined below.

Processing and Preparation of frozen dalo for export

The skin of the dalo should be completely removed and the dalo cut into even sized pieces.

The size of the pieces help to ensure consistent cooking times of the frozen product by the customer. Large pieces of dalo can take longer for consumers to cook, and irregular sizes can result in the dalo being unevenly cooked. The processed dalo also should be an attractive shape for the customer (dalo slices are a common form of presentation).



Blanching or dipping

Most vegetables are blanched prior to freezing. Blanching requires the vegetables to be briefly boiled or steamed in order to inactivate enzymes. Blanching can also help to remove contaminating microorganisms. By reducing enzyme activity blanching helps to preserve the dalo and prevent off-flavours, discolouration, and destruction of nutrients. The dalo should be quickly cooled after blanching to prevent over-cooking.

Alternative preserving treatments includes dipping dalo in sodium metabisulphite. The sodium metabisulphate is a preservative, which inhibits the growth of fungi and bacteria. After washing the dalo is dipped in a sodium metabisulphite solution before the dalo is packed and put into a blast freezer or container. Care needs to be taken to ensure that the concentration of the sodium metabisulphite solution and the dipping time is appropriate to ensure there are not excessive concentrations in the dalo.

Packing

The blanched, cooled and drained dalo is placed in a container, usually in plastic bags, for freezing. Dalo may also be vacuum packed prior to freezing, which may offer advantages for improved shelf life. Some varieties of dalo can be sticky when cooked, so care needs to be taken to make sure that pieces remain separate during subsequent freezing.

Freezing

The taro is then frozen preferably using a blast freezer at -18°C . It is important that during blast freezing the bags of dalo are packed to allow even circulation of air around them. This allows them to be rapidly and evenly frozen to maintain quality. Once frozen the dalo can then be transferred to a commercial freezer. The commercial freezer should maintain a temperature of -18°C .

Shipment

Once frozen it is important to ensure that the frozen dalo remains frozen. Thawing will result in a decline in the quality of the dalo and may render the dalo inedible. Quality frozen dalo requires the dalo to be continuously frozen during its handling and shipment to export markets.

Drying and conditioning

Following washing operations corms must be moved to a pest and contaminant free area for drying. This area should be away from the area used for trimming and washing to prevent the clean dalo from becoming contaminated by pests and material that had been removed during trimming and washing.

Corms are usually placed on a clean mesh-type rack that allows adequate air circulation around the corms. In practise corms are often left to let the water drip dry for 15-30 minutes before packaging, however best practise is to allow the surface of the dalo to thoroughly dry prior to packing. It is important that corms are not packaged wet as this will lead to an increased incidence of post-harvest fungal infections of the corms in the receiving country, which in-turn may lead to biosecurity issues and reduced shelf life of the product.

- Following washing, corms must be moved to a contaminant free area for drying. Corms should be placed on a clean rack that allows adequate air circulation around the corms.



Packaging

After drying the corms are packed into new, clean packaging. Woven polypropylene sacks are generally used for exported dalo. Laminated polypropylene sacks have an advantage over non-laminated sacks in that they assist in reducing moisture loss, resulting in fresher corms arriving at the destination market. Corms should be packed in a manner that ensures sacks are not overfilled. Once packed, sacks should be sewn/tied closed to prevent contamination. Where sacks are not transferred directly into a refrigerated sea container or air container they must be stored in a clean area free from pests and other contaminants.

The packaging area must be cleaned regularly, preferably throughout the day, but at the very least at the end of the day. All waste from the peelings should be removed immediately and either buried or taken away from the vicinity of the pack house.

- New, clean, packaging must be used for export dalo. Packages must be sewn or tied closed and labeled. Prior to loading, store packaged corms in a clean area free from pests and other contaminants.



Final inspection

A final inspection must be undertaken by the exporter, or exporter delegate (quality controller), prior to the export inspection by the Biosecurity Authority of Fiji (BAF). A representative sample of packaged dalo corms is drawn randomly from the consignment by the quality controller. The size of the sample must provide the quality controller with confidence that the sample is truly representative of the consignment. Particular attention should be given to immature, misshapen, physically damaged, and under- or over-sized corms, as well as corms displaying disease symptoms or signs of pest infestation. Magnification (eg. a low power hand lens or maggylamp) should be used to investigate any suspect corms. Where it is found that corms do not meet the biosecurity standards of the importing country the consignment must be rejected for export. The consignment must be treated or reconditioned (as appropriate) before it can be submitted for BAF export inspection. Alternatively, the consignment can be diverted to another market.

- A final inspection must be undertaken following packing. Any corms that do not meet export quality or biosecurity requirements must be removed from the export pathway. The use of low power magnification to investigate suspect corms is recommended. Inspection records for each consignment of dalo must be retained.



Storage

Cool storage facilities at each packhouse need to be cleaned regularly with antiseptic and temperature be maintained with minimal fluctuations. Authorized personnel only should enter these facilities ensuring hygiene of the cooling facility and the workers.

- Sea and air containers must be free of soil, pests and other contaminants prior to packing.
- Maintain refrigerated containers at 8-10°C during storage and shipping.



**Appendix 1.
Producing
fresh dalo
leaves for
sale and
export**



Good agricultural practises

Dalo leaves are used in cooking across the Pacific Countries, but also in many Asian countries (including Malaysia, Indonesia and the Phillipines). Dalo leaves must be cooked or processed in some way before they are eaten to break down the crystals of calcium oxalate that cause itchiness. Usually this occurs during cooking, but in the Phillipines this is done by drying the leaves. Dalo leaves tend to either be used in cooking in one of two ways, either chopped and cooked by steaming, baking, boiling or frying as a vegetable (e.g. rourou) or used to wrap up a parcel of food and then cooked by baking, steaming or boiling (e.g. palusami).

For use as a fresh vegetable young, tender leaves are preferred. When taro leaves are used to wrap and cook food larger leaves tend to be used in the outside layer and smaller leaves placed on the inside. Only fresh leaves are suitable for using in stuffed recipes.

Leaves should be fresh, clean, dark green in colour and uniformly shaped. Customer preferences for appearance (including colour) and leaf characteristics need to be considered when growing dalo leaves for export markets. Some customers look for green leaves with a green petiole (stem), whilst others may look for varieties with darker leaves and petioles. The leaves should be free from blemishes such as signs of insect or virus damage. Ensuring the dalo leaves have a good appearance and that they arrive in markets fresh can be challenging.

Dalo leaves can be exported fresh, or precooked (such as blanching). There has not been much formal work done on examining the best characteristics and varieties for dalo leaf production. Dalo ni wai, Wararasa and Kurokece are varieties with green leaves and petioles which have been used for dalo leaf production.

Dalo leaves can be harvested from crops grown for dalo corms, however depending on how often dalo leaves are collected this can have an impact on the size of the dalo corm at harvest. Some farms produce dalo only for leaves. The practises used to produce dalo corms for export and dalo leaves are similar, except dalo leaf production need a focus on preventing damage to the leaves and ensuring continual growth and production so that leaves can be harvested consistently.

Considerations when selecting and preparing a crop site for dalo leaf production including making sure that the farm is easily accessible and that there is good access to transport. Also that there is access to clean water so that dalo leaves can be washed after harvest. It can be useful to irrigate the dalo crop to help ensure that there is consistent production of leaves. Because of the importance of producing undamaged leaves farmers may need to also consider changing to wider plant spacing to reduce damage by wind or from people walking past plants.

During the production season a different fertiliser schedule might be required to ensure that there is good leaf production. This may require some experimentation by the farmer to find an ideal solution. Weed control is important, as weeds can compete for water and nutrients as well as harbour pests that might cause damage to the dalo leaves.

Irrigation and good nutrition of the dalo plants can help reduce pest problems, however crops should be regularly checked for pests such as mealybugs, thrips, caterpillars, plant hoppers, aphids and white fly. Plant hoppers, aphids and white fly can spread viruses which spoil the appearance of leaves. Leaves with virus damage should be removed from the plant to prevent further spread of the virus.



Good harvest and handling practises

Dalo leaves should be picked early in the morning and transported to market as quickly as possible to ensure that they stay fresh.

For local markets the picked leaves should be washed carefully in drinking quality water and the leaves can then be loosely bundled and wrapped for transport. Leaves being taken to local markets tend to be wrapped in either banana or via leaves, alternatively they can be wrapped in clean damp paper. It is important that the bundled leaves are stored in cool, shady locations as much as possible. Leaves which have been covered, placed in plastic bags and stored in a cool location may last for a day or two³. When transporting the leaves it is important that there is nothing placed on top of them which might cause damage, and where possible they are placed so that they do not move around during transport.



Pathway to export markets for dalo leaves



Collection and transport

Fresh dalo leaves should be collected by the exporter's representative or delivered directly to the packhouse by the farmer. To avoid damage to the leaves it may be best that the leaves are provided to the exporter unwashed and packed loosely in bundles to prevent excessive handling. When dalo leaves are being transported to exporters it is best to avoid wrapping them in banana leaves or via leaves as this might transfer pests and diseases onto the dalo leaves. Leaves should be transported carefully taking care that they are not physically damaged or over-heated.

Exporters should be clear about any specific requirements for size, variety etc. when negotiating orders with farmers.



³ Goebel, R., Taylor, M. and Lyons, G. "Leafy green vegetables in the tropics Fact Sheet no.2. Taro Leaf" Feasibility study on increasing the consumption of nutritionally-rich leafy vegetables by indigenous communities in Samoa, Solomon Islands and Northern Australia. PC/2010/063. Australian Centre for International Agricultural Research (ACIAR)

Grading at packhouse

At the packhouse leaves should be graded to check they are free from damage and disease, and that there are no pests. Leaves could also be graded so that they are uniform in size and colour.

Any damaged leaves or leaves with signs of pests and disease should be discarded, taking care that they do not contaminate clean leaves.



Washing

Leaves should be washed in drinking quality water to ensure that they are clean. In deliveries of leaves where there is evidence of insects being present it may be appropriate to dip the leaves in salt solution or similar to help ensure there is no contamination.

The leaves should then be dipped in iced water to cool them and help prepare them for storage. The leaves should then be drained, air dried and free from excess moisture. At this point the leaves should be free of any foreign materials, including dirt, seeds or any other plant materials.

Packing

The washed and dried leaves can be bundled or grouped and then wrapped in new absorbent paper or food grade plastic bags. The wrapped leaves can then be packed into new perforated cartons.



Cooling

The perforated cartons should be transferred to a cool store and brought to an appropriate temperature and humidity for transport.

Shipment

Once appropriately cooled the cartons should be transferred to containers for shipping. It is important that humidity and temperature of the dalo leaves be maintained throughout the journey to their destination in order to maintain their quality.

Because of the perishable nature of the dalo leaves it is important that they are transported to the export market as quickly as possible, generally by air freight within 24 hours of the dalo leaves being picked.



**Appendix 2.
Import
requirements
for dalo
exported to
Australia and
New Zealand**

The requirements for fresh dalo exported to Australia and New Zealand are currently



For Australia⁴

- a. These import conditions apply to the following fresh produce for human consumption: Taro (large corm) tubers (*Colocasia esculenta* var. *esculenta*).
- b. A Department of Agriculture and Water Resources import permit is not required, providing that the following conditions are met.
- c. Prior to export, the plants or plant products must be inspected or tested by the National Plant Protection Organisation (NPPO) and certified free from biosecurity pests.

The taro must have been sourced from a country free from taro leaf blight (*Phytophthora colocasiae*).

To demonstrate compliance with this requirement you must present the following on a Phytosanitary certificate:

The additional declaration “The tubers have been sourced from [Name of country], which is free of taro leaf blight (*Phytophthora colocasiae*).”

- d. The taro must be *Colocasia esculenta* var. *esculenta* and have been inspected, topped and free from all foliage.

To demonstrate compliance with this requirement you must present the following on a Phytosanitary certificate:

The additional declaration “The taro in this consignment is *Colocasia esculenta* var. *esculenta* and not *Colocasia esculenta* var. *antiquorum*.”

AND

The additional declaration “The tubers have been inspected and are topped and free from all foliage including petiole bases, and free from sprouting suckers and attached daughter corms.”

- e. An original phytosanitary certificate must accompany each consignment.

⁴ As of September 2018. Sourced from Department of Agriculture and Water Resources BICON database.

- f. The goods must be clean and free of biosecurity pests and disease, contaminant seed, soil, animal and plant debris and other biosecurity risk material prior to arrival in Australian territory.
- g. Only fresh large taro tubers of the species *Colocasia esculenta* var. *esculenta* are permitted. Tubers of the small corm taro *Colocasia esculenta* var. *antiquorum* are not permitted entry. Permitted fresh large taro tubers must comply with the morphological criteria below.

Specifically the taro must:

1. be at least 15 cm long or be at least 7 cm in diameter at the widest point
 2. be at least 300 g in weight
 3. be free of lateral buds or shoots
 4. lack shaggy hairs.
- h. Each consignment must be packed in clean and new packaging.
 - i. Each consignment must be secured (i.e. made insect-proof) prior to shipment to maintain its quarantine integrity on arrival using a secure packaging option.
 - j. All consignments are subject to inspection on arrival to verify compliance with import conditions before release.
 - k. Land-bridging of consignments under biosecurity control is not permitted without permission from the Department of Agriculture and Water Resources. Air and sea underbond movement of consignments for inspection at the port of destination is permitted.
 - l. If live insects of biosecurity concern are detected the consignment will require treatment (where appropriate), or be exported or disposed of. Any required action will be at the importer's expense.
 - m. If disease symptoms are detected the consignment will be placed on hold and an assessment of the biosecurity risk will be made by the department to determine the options available to the importer. Options may include release, further identification,

treatment, export or disposal.

Further identification may not result in the release of the goods and may incur substantial additional costs and time delays for the importer. Further identification will only be offered if it is deemed feasible and the importer agrees in writing to accept all costs and risks involved.

- n. If contaminants (e.g. seeds, trash, soil, feathers) are detected and determined to be of biosecurity concern, the consignment will require remedial action to remove or treat the contaminants, and will require re-inspection. If the contaminants cannot be effectively removed or treated, the consignment must be exported or disposed of. Any required action will be at the importer's expense.
- o. Under the Biosecurity Charges Imposition (General) Regulation 2016 and Chapter 9, Part 2 of the Biosecurity Regulation 2016, fees are payable to the Department of Agriculture and Water Resources for all services. Detail on how the department applies fees and levies may be found in the charging guidelines.
- p. In addition to the conditions for the goods being imported, non-commodity concerns must be assessed including container cleanliness, packaging and destination concerns, and may be subject to inspection and treatment on arrival. Please refer to the BICON Non-Commodity Cargo Clearance case for further information.
- q. Once biosecurity requirements have been met, it is the importer's responsibility to ensure that all imported food complies with the Imported Food Control Act 1992 including Australia New Zealand Food Standards Code. Consignments of food may be referred for inspection and analysis under the Imported Food Inspection Scheme to verify compliance. Some foods, such as beef and raw milk cheese, are not permitted to be imported without government certification.



For New Zealand⁵

Fresh dalo from Fiji must meet the generic import requirements for all fresh fruit and vegetables permitted into New Zealand.

A Phytosanitary Certificate must accompany all consignments to certify that the dalo has been inspected and considered to be free from visually detectable quarantine pests.

Packaging associated with fresh fruit/vegetables must be clean, free from soil and other contaminants.

⁵ As of September 2018. Sourced from Ministry for Primary Industries website.



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