Citrus Packhouse

Module 1:
Packhouse Overview

Learner Guide

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Citrus Growers' Association OF SOUTHERN AFRICA
Grower levies working for you!

1st edition 2022

The content of this module is based on audio-visual material produced by the Citrus Academy.

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Introduction

Citrus packhouses are vital in producing citrus fruit that is marketable, healthy, and ready for export. The packing process involves many different activities, from washing, de-greening, and treating fruit, to sorting, grading, labelling, wrapping and packing. This means that there are a lot of people and machinery involved in the process, and there are many places where things can go wrong. Understanding the components, personnel, equipment and machinery involved throughout the packing process is the first and most important step to owning, supervising, managing or working in a packhouse efficiently and effectively.

Every citrus packhouse is different – there are no standard designs or rules about what a packhouse should look like. Packhouses are designed based on the volume of fruit they handle, the types of citrus and other fruit they pack, the needs of the growers whose fruit is being packed there, and the requirements of the markets the fruit will go to. In South Africa we get packhouses that range from packing 50,000 export cartons per year, to packhouses that pack almost 3 million cartons per year.

Whether the packhouse packs a few hundred boxes or thousands of boxes every day, it really does not make much of a difference to the packhouse process. The aim of all packhouses is the same: to process fruit coming from the orchard and deliver the best quality product possible.

It is critical to remember that we are all exporting under Brand SA and that we are all responsible for how South African fruit is perceived in the overseas market. Every action that every person in the packhouse takes, or neglects to take, can impact how fruit from South Africa is perceived overseas. Never allow a product to leave the packhouse that you are not happy to call proudly South African.

Production and Picking

Producing export-quality citrus fruit starts in the orchard. Best practices for the production of quality citrus is well-established, and the Citrus Academy has a range of programmes, learning material and audio-visual modules available on this subject.

When the fruit is physiologically mature, it is picked and taken to the packhouse. Picking export citrus is a specialised task, and care must be taken to preserve the fruit quality and safety while being picked. Please see the Citrus Academy audio-visual modules on Citrus Harvesting to learn more.

Poor picking practices cause problems in the packhouse. For instance, if pickers leave long stems on the fruit, it can damage other fruit in picking bags and bins during transport to and handling in the packhouse. The packhouse must give fast, accurate, and regular feedback to the farm management and picking teams so that picking practices can be improved if necessary.

Always remember: a packhouse is not a hospital for sick fruit. It is not possible to heal sick fruit or improve fruit quality in the packhouse. External and internal fruit quality is determined during pre-harvest production. The purpose of the packhouse is to preserve the quality of the fruit while preparing it for export, by cleaning it, treating it to prevent the development of postharvest diseases, improving the fruit's appearance and shelf-life, separating it into size and class categories, and packaging it as per market requirements.

Packhouse Process Flow

Let's take a look in more detail at all these activities that make up the packhouse process. The model that we use here includes all the actions and processes in a typical export citrus packhouse, even though how this looks in practice might differ from packhouse to packhouse.

The packhouse process can be divided into three parts, namely receiving and initial processing, treatments and separation, and packaging, after which the fruit is inspected and transported from the packhouse.

There are also general operations that apply throughout the packhouse process. The packhouse must be kept clean and sanitary, the fruit must meet food safety standards, the quality of the process must be monitored, and all workers have to maintain a high level of personal hygiene and adhere to health and safety regulations.

Receiving and Initial Processing

The fruit arrives from the orchard in picking trailers or in bulk bins stacked on trucks or trailers. It is essential to record all relevant details of each delivery on arrival, such as the date, time, weight, citrus type and cultivar, production unit details and orchard details, as well as the details of the grower in packhouses where fruit of more than one grower is packed. If the fruit has to be de-greened, the colour of the fruit on arrival must also be noted, and the bins must be marked.

At this point, depending on the destination market, it may be necessary to conduct a packhouse delivery inspection for false codling moth and fruit fly infestation. Citrus black spot monitoring is also done in areas where it is a risk. Please see the Citrus Academy audio-visual module on Monitoring and Inspection for Phytosanitary Markets for Citrus for more information.

De-greening is a process which can be applied to fruit that complies with internal quality requirements, which means that they have reached the minimum sugar and acid levels, but have not yet achieved the right colour. De-greening allows growers to get fruit to the market early and before the fruit would develop colour naturally. It is also used when waiting longer for fruit to colour naturally may result in deterioration of the internal quality. It is used mostly towards the start of the harvesting period of each citrus type, but the decision to de-green primarily depends on fruit colour and it can therefore be done at any time.

The process involves exposing fruit to ethylene gas in de-greening rooms for a specific period, until they have reached the right colour. Because the rooms are warm and humid, they offer favourable conditions for the development of fungal diseases, which is why fruit destined for de-greening is drenched with a fungicide treatment before de-greening. Fruit that is stored for extended periods before being processed in the packhouse is also drenched to protect it against decay.

Fruit enters the packline and is washed in a wet or dry tip system. In a wet tip, bins are emptied into a bath of water containing a sanitiser. In a dry tip, bins are emptied onto a conveyor belt after which the fruit is washed with brushes and a spray, using a sanitising solution to control harmful microorganisms. A similar washing system may also be found on lines that use wet tipping.

After fruit has been washed, it is pre-sorted before being processed further. Pre-sorting has two main aims. The first is to remove all fruit that is clearly infected with diseases – if such fruit is let into the packhouse it will infect other fruit and contaminate the

system. The second aim is to remove fruit clearly not suitable for export because of size, colour or blemishes. Any further treatment or processing of such fruit is a waste of money and time.

Treatments and Separation

After pre-sorting, fruit is treated with fungicides in a bath or a flooder to cure young infections that can cause postharvest decay. These young infections cannot be seen with the naked eye, so pickers and pre-sorters may miss them. After this treatment, the fruit is put through a drying tunnel so that it is dry before being waxed. Wax is applied to fruit to prevent moisture loss through the rind, to enhance their appearance, and, sometimes, to apply fungicides that offer long-term protection. After the wax application, the fruit goes through another drying tunnel.

Fruit of the same grade and size is packed together, so before it can be packed, the fruit is separated according to size and quality. At the same time, fruit not fit for export is redirected to local market packline or processing lines. Sophisticated machinery is used for this purpose, but in most packhouses manual sorting is also used, either before or after treatments. In some packhouses, there can be as many as three manual sorting stations if we include pre-sorting.

Packing

Once fruit has been sorted and graded, they are labelled, if required by the destination market. Fruit labelling machines are used for this purpose in most packhouses, although manual labelling is still used in some cases.

Fruit is now ready to be packed in size and grade categories, and according to the requirements of the market. The market requirements also determine what size and type of carton the fruit is packed into, and whether the fruit is wrapped or not. In some packhouses, automatic packing machines are used. Cartons are labelled in accordance with market specifications.

Cartons are stacked on pallets, with the stacking patterns depending on the type of carton. Corner pieces and strapping are used to stabilise and secure the pallets. For open-top display cartons, securing sheets and pallet caps are also used.

Inspection and Transport

After palletisation, inspectors from the Perishable Products Export Control Board, or PPECB, inspect the packed and palletised fruit to make sure that it complies with the minimum requirements for export to the destination market. The pallets are then stored until they are loaded for transport to the harbour, either by road or rail. In some cases, shipping containers are stuffed with pallets at the packhouse, and then secured and transported to the harbour. Alternatively, loose pallets are loaded and transported.

General Operations

Maintaining the quality and safety of the fruit as it goes through the packhouse process is critical to successful packhouse operations. To achieve this, the packhouse environment and all the equipment used in the packhouse must be kept clean and sanitary at all times. Packhouse workers must also adhere to strict personal health and hygiene standards.

Quality control checks must also be in place, to ensure that treatment protocols are adhered to, grading and sizing are being done correctly, that fruit is not injured during the packing process, and that the right fruit ends up in the right place.

A packhouse can be a dangerous working environment, with the machinery, equipment and chemicals that are used in the packhouse process all posing risks. Packhouse management must ensure that all workers in the packhouse environment understand what is expected from them with regard to occupational health and safety, and adhere to protocols and standards at all times.

Citrus Industry Extension Services

The requirements of overseas markets are constantly evolving, as is our technical knowledge and understanding of packhouse processes, treatment chemicals, and packing materials. Packhouses need the support of dependable, objective research and extension services to enable them to keep abreast of the latest developments and maintain the standards required by export markets.

The Citrus Growers' Association of Southern Africa is a non-profit organisation that is funded through a levy on all export citrus. From this levy, the CGA funds Citrus Research International, a world-class scientific research organisation. CRI belongs to the citrus growers, and their mandate is to support and grow the citrus industry through reliable and applicable research, and accessible extension services. Aside from citrus production practices, CRI also invests in extensive research on postharvest practices, including the packhouse process.

CRI regularly issues information and recommendations to packhouses in southern Africa on packing practices, protocols and chemical use. CRI also sets minimum standards for packing material to ensure that fruit can be transported safely and securely once packed.

CRI is an invaluable source of information and assistance available to all citrus packhouses in southern Africa. CRI has no profit motive, and only has the best interests and welfare of the citrus industry at heart. Their recommendations and advice can always be trusted.

Citrus Packhouse

Module 2:
Packhouse Infrastructure and Planning

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Introduction

Citrus packhouses come in many shapes and sizes. There are packhouses in operation today that were originally built in 1923, and some that are brand new and ultra-modern. They all perform the same function, and hopefully the packed citrus that is dispatched is all of the same high standard, but they do this with varying degrees of efficiency and consistency, and at vastly varying costs.

Before we look at the thinking processes and planning that goes into building a new packhouse, let's take a look at the infrastructure required by packhouses.

Packhouse Infrastructure

Fruit packhouses are highly industrialised operations, mostly found in very rural settings. Some packhouses are in small towns, but many are on farms. The infrastructure in these areas was generally not developed to accommodate industrialised operations, and it is therefore crucial to be aware of the infrastructure requirements for packhouses, and to consider the ways in which these requirements can be met where external infrastructure is not readily available.

Land

The land on which the packhouse is built should be as flat as possible, and large enough to accommodate the packhouse building, storage facilities, receiving and dispatch areas and staff accommodation, if required.

The land should be easily accessible from a national road, and should have a connection to a rail line and sufficient space for loading onto rail, if that is going to be used. The packhouse should also be accessible from the orchards where the fruit is grown.

When a new packhouse is being planned, a geotechnical study should be conducted to investigate the soil, rock and bedrock. This is done to ensure that there are no features that may be problematic in the future, and to forecast the costs of earthworks during construction.

Access Roads

Picked fruit is transported to the packhouse and, in turn, packed fruit is transported from the packhouse in massive volumes during the season. Access roads are also used by packhouse workers and by service providers. The accessibility of a packhouse can have a significant impact on the efficiency of its operations.

Roads coming from the orchards should be laid out so that the fruit travels the shortest possible distance to get to the packhouse – the longer the fruit spends on farm roads, the dustier it will get, and the greater the danger of injury and bruising. Roads must be kept in a good condition, and bridges, cattle grids and other features on farm roads should be maintained to ensure the smoothest ride possible. Dust can be detrimental to trees and fruit, so dust suppression by keeping roads wet, speed bumps, and signage on main roads reminding drivers to drive slowly, should be in place.

The packhouse should have easy access to a national road to limit truck traffic on farm roads and to facilitate worker transport. If the traffic turning into and out of the packhouse from the national road exceeds a certain limit, legislation requires the

construction of a special turn-off to the facility. This turn-off must be constructed by the National Roads Agency, at the cost of the packhouse. Therefore, this cost must be taken into account when a new packhouse is being planned.

Water Supply

Water is a critical requirement for packhouse operations. The availability of sufficient water is a decisive factor when a new packhouse is being considered. The quality of the water can be improved and managed, albeit with a significant impact on ongoing packhouse operations and costs, but sustainable supply is critical.

Important water quality factors for packhouse operations include physical particles, total dissolved solids, bacterial contamination, and pH value.

Physical contaminants that can be found in water include inorganic materials such as clay, silt and sand, as well as organic debris such as plant remnants, seeds, and aquatic flora and fauna. These physical particles can cause blockages in washing and treatment systems in the packhouse and can collect in pipes. If the water available has high levels of physical contaminants, flocculation and filtration can be used to remove particles before the water enters the packhouse.

The total dissolved solids, or TDS, refer to the inorganic salts and small amounts of organic matter in solution in water. It is thought to have an impact on the efficacy of certain treatment chemicals, and for this reason this value should be measured and monitored. There is not much one can do to improve high TDS, and if the values are completely out of the acceptable range, it may be necessary to use water from a different source for certain purposes. Modern filtration systems and water purifiers can lend some assistance at a considerable cost, but where water sources are limited, it is a feasible option.

Water with high levels of bacterial contamination is dangerous in the packhouse because it decreases the efficacy of fungicides and other treatment chemicals, and can also cause contamination of washing systems. If the bacterial contamination in the water is too high, the water must be sanitised before entering the packhouse.

The pH value of water can reduce the efficacy of fungicides, to the point of rendering them completely ineffective. The efficacy of chlorine as a sanitiser is also impacted by the pH level of the water – chlorine is three times more effective at pH7 than at pH8. The pH of incoming water can be corrected, but the decision of how and where to do this depends on how severe the problem is. If it is extreme, all incoming water will have to be treated, which is a costly exercise. Alternatively, only the water that is used in washing and treatment systems may require treatment.

Water is sourced from boreholes, rivers, canal systems, or the local municipality, with rainwater harvesting recently becoming a popular choice. Dams are used in combination with most water sources to ensure that there is always water available to the packhouse should there be an interruption of supply from the primary source.

Water from boreholes is usually of good quality, and in most cases does not require treatment to make it fit for use, although high mineral and salt content are problems sometimes associated with borehole water. It is important to ensure that the water supply from boreholes is consistent and dependable. Municipal water should likewise be fit for use, although the water quality should still be monitored regularly.

Water sourced from rivers and canals must be treated and purified before it can be used. Water treatment plants would usually include flocculation with a settling dam and filter banks, along with other equipment to address specific issues. Water testing

should be conducted regularly to monitor water quality and the effectiveness of the treatments. It is also important to be aware of other activities in the area that may affect water sources. For instance, if there is a mining operation upstream from the packhouse, it is critical to monitor water quality closely and to test for heavy metals and industrial pollution. In times of drought water quality can be negatively impacted, even from sources that are normally dependable, and it is especially important to monitor water quality and conserve water at those times.

Rainwater harvesting is becoming more popular in many areas. The rule of thumb is that 1 litre of water can be harvested from 1 square metre of roof area for every millimetre of rain. Packhouses generally have large roof areas, making them ideal for rainwater harvesting even in regions with relatively low annual rainfall. Rainwater is also usually pure and does not require any treatment before being used, although it may pick up dirt from the roof, especially during the first rains after a dry spell. It is therefore still advisable to test the water from time to time. However, storage capacity is a critical factor, and provision must be made for larger storage dams if rainwater harvesting is used.

Because packhouses are so dependent on water supply for their operations, it is very important for every packhouse to have a backup water supply. Many things can happen to interrupt water supply from a primary source. Municipal systems can break down, rivers and canals can run dry, borehole pumps can break. Even if the interruption of supply is very short, it can have a devastating impact on operations during peak season. Every packhouse needs a backup plan for water supply, and should have spare capacity that can be used in cases of emergency.

Another emerging issue is managing water that has been used in the packhouse. Water that was used in treatment and washing systems must be disposed of responsibly, as it can be detrimental to the natural environment. Although the setup costs of a water recycling facility can be high, it significantly reduces the environmental impact of a packhouse and the use of primary water sources. Many packhouse accreditation schemes require sound water management practices as part of environmental responsibility.

Electricity Supply

Electricity is the second critical supply factor for a packhouse. As with water, a packhouse without electricity cannot operate at all.

Electricity is typically supplied to packhouses by Eskom, but all packhouses need the ability to generate their own electricity, and as such generators are a common sight at packhouses. Although the operational costs may be high, the cost of being without electricity supply for even a short time in the packing season is even higher.

Solar electricity is becoming more popular as packhouses look for more sustainable and dependable sources. Storage equipment, such as batteries and inverters, used to be prohibitively expensive for the capacity needed to run a packhouse. However, the technology is improving rapidly and, with many more manufacturers and suppliers entering the market, it has become a feasible option. Therefore, this is likely to be the best way forward. Other sources of renewable energy are also being developed and tested, and will become viable and affordable over time. As an example, hydro-electrical power is a good option for a packhouse situated near a river.

Connectivity

A new generation packhouse cannot operate without being connected to the outside world. Modern operational systems in the packhouse require high-speed internet or cell phone connection, not to mention the need for staying in touch with markets, suppliers, staff, and so on.

If the packhouse is in an area where there are poor connectivity services, it may be necessary to invest in infrastructure such as a satellite connection.

Packhouse Planning

Building a new generation citrus packhouse is extremely expensive and requires a massive capital investment. Apart from this, operating these packhouses requires specialised skills, which are often scarce, especially in rural areas.

The decision on whether building a new packhouse is a viable proposition requires very careful investigation, with many factors to consider. A few of the questions that should be answered include:

- Do the volumes of current production and future expansion justify a new packhouse?
- Will the packhouse be running for long enough each year to make it financially viable?
- Are there other packhouses in the area with spare capacity as an alternative to building a new packhouse?
- Is there suitable land, sufficient water and electricity available for the packhouse?
- Is there a sufficient labour force available in the area, or can they be brought in?
- Are there people with the critical skills needed for operating the packhouse?

Take into account that, even though the packhouse will only run for part of the year, overhead expenses must be paid year-round, including the salaries of critical staff members who cannot be let go of at the end of a season, because they need to be retained for the following season. Every day a packhouse stands idle is a day without return on the capital investment. For this reason, many citrus packhouses are built to accommodate the packing of other tree crops, such as mangoes, avocados and, with some well-planned line adjustments, even stone fruit.

Once the decision has been taken to build a new packhouse, the planning process starts. Ideally, one should have three years to plan before the first phase of construction starts. The machinery alone needs to be ordered at least one year in advance, and this three-year timeframe also allows time for advice, testing assumptions, and consulting experts in the industry.

The lifespan for packhouse machinery and equipment is ten to twelve years if you want to stay current with technology, but the building itself can stand for a very long time. Think very carefully about planning the layout of the building so that it allows for expansion without compromising efficiency.

It is a very good idea to get help from an industrial architect when designing a packhouse. Their professional fees might be considerable, but they can add value in many ways that will bring about savings in costs, time, and efficiency over the lifespan of the packhouse. Additionally, assistance from various other professionals will be required in the planning process, such as environmental experts, geohydrologists, etc.

Laws and Regulations

Before starting the planning process, it is essential to investigate and study all the regulations and laws that may have a bearing on the packhouse site and operations. These include regulations around access roads, as well as the bylaws and regulations of the local municipality. For instance, if the packhouse is going to pack fruit for growers other than the packhouse owner, the zoning for the land will have to be changed to agro-industrial, which can have substantial cost implications. Even if the packhouse is not located in a municipal area, the district municipality may still have regulations and requirements that will apply to it, such as an environmental impact assessment for the site. Many municipalities closely monitor industrial developments for transgressions of environmental bylaws, with particularly hefty fines being imposed.

Fire Prevention

Fire prevention has become a priority for many municipalities, and it is now a requirement in many parts of the country that buildings such as packhouses have fire prevention and control systems in place. Typically, this involves a sprinkler system that is installed throughout the packhouse, and storage dams that are dedicated to fire prevention that feed this sprinkler system. Installing such a system is very expensive, but when compared to the cost of losing the packhouse in a fire, there is no comparison. A truly destructive fire can leave growers without a way to pack any fruit for the next two seasons while the packhouse is being reconstructed, while leaving hundreds of people out of work.

Packhouse Planning Principles

The main principle of planning a packhouse is to begin with the end in mind. Do not be tempted to design a solution for immediate challenges, but look at what the packhouse will have to do when running at full capacity; and even what the packhouse will look like in ten, fifteen, and twenty years from when it starts operating. It is important to decide from the start whose fruit the packhouse will be packing, and to gather information from these production units regarding the projected production volumes that the packhouse will have to process over time.

While beginning with the end in mind is the principle of packhouse planning and design, the basis for every decision, from site layout, to electricity and water supply systems, to machinery manufacturers, to automation, to staffing, is efficiency, consistency and cost-effectiveness. Because they are so expensive to establish, new generation packhouses cannot afford inefficiencies, interruptions, inconsistent quality, or wastage.

Packhouse Production Capacity

The first step in calculating the packhouse capacity is to list all the citrus types and cultivars that the packhouse will likely be packing, along with the expected volumes. For each cultivar, determine the picking window and the curve that fruit deliveries are likely to follow over the picking window, taking into account that the peak is likely to be around the middle of the picking window. Ideally, base these calculations on historical production and picking data from the area.

Combine the curves for all the types and cultivars to get the volume of fruit that will be delivered to the packhouse during the season at peak times.

These curves can be drawn for a few years to provide for orchard expansion and increased production, and this information is then used to plan the packhouse development phases. If the development can be phased, the capital investment will also be spread over time.

It is not always feasible to design a packhouse to handle the maximum volume that will be processed in peak times or at maximum capacity, because this means that at all other times the packhouse will be running below capacity, meaning that most of the time the packhouse will not get full value from the capital investment. One option is to plan the capacity for a percentage of the maximum volume, for example 80%, and to find other packhouses in the area with spare capacity that can pack the remainder.

The other alternative is to use de-greening to flatten the peaks, thus decreasing the maximum volume and extending the period for which the packhouse will run at maximum capacity. However, this will require more expenditure on pre-sorting, de-greening facilities, and storage space. It is also important to remember that de-greening is detrimental to fruit quality and should be used sparingly.

The above discussion assumes that packhouse capacity will not be constrained by the availability of land, water, electricity, a labour force, or capital. If there are such constraints, the production curves should be adjusted accordingly.

Using the combined production curves, the monthly and weekly volumes that will be processed at the packhouse can be forecast. Working on a 5-day workweek, leaving weekends for maintenance and packhouse sanitation, the daily volumes that the packhouse will have to handle can also be calculated. These will be the volumes received and processed in the packhouse. Adding a projected pack-out percentage, meaning the percentage of fruit received that will be exported, allows for the calculation of the cartons and pallets that will be packed and stacked per day. This is referred to as the throughput of the packhouse.

Packhouse Site Layout

The packhouse site can be divided into six functional areas, namely: receiving, the production area, dispatch, water and energy supply, the carton store, and staff areas which includes the administration offices, and the staff canteen and ablutions.

The receiving area is typically near the entrance from the roads leading to the production units, while the dispatch area would usually be near the entrance leading from the national road. The receiving area must be large enough to store all the fruit that is received until it can be processed, and must have easy access to the drench and de-greening rooms, but should be isolated from the main production area to limit the spread of dust and spores to clean fruit. It is strongly recommended that this area should be under roof to protect the fruit, especially if fruit could be stored for extended periods, such as over weekends.

The dispatch area includes the storage space where pallets are kept before being loaded. Based on the throughput that has been calculated, we know how many pallets should be packed every day during peak season. We now need to decide for how many days' production we will need storage space, taking into account the likely logistics and transport availability in peak season. Inspections are also conducted in the dispatch storage area, and provision should be made for a separate space for pallets that have been inspected and those that are still awaiting inspection. The PPECB also requires a small laboratory space, for organoleptic quality testing and titrations. Space must also be available to repack pallets that have been rejected during inspection, or that need to be re-palletised for another reason.

Racking is becoming a popular option to store pallets awaiting dispatch. It is much cheaper to increase the height of a building than it is to increase the floor space, and racking is a handy solution to optimise storage floor space. Pallets can be racked up to four high, increasing the number of pallets that can be stored fourfold. Racking has another advantage, since every pallet can be easily reached without first having to move other pallets out of the way.

A decision also must be made on whether the packhouse should have cold storage. This decision rests on what citrus types are packed at the packhouse, how long fruit is to be stored before being dispatched, what markets the fruit is destined for, and how far the packhouse is from the port.

The packlines are in the packhouse production area. In the next section we take a look at packhouse equipment and machinery, and discuss the packlines in more detail.

Water and energy supply is where the water storage dams, including the fire prevention dams, the water treatment plant, and the equipment for electricity supply and generation, including the Eskom transformer, the generators and solar stations, can be found. In many packhouses energy sources including gas, diesel or paraffin are used for heating, such as in drying tunnels, and these fuels also need a secure storage space on the packhouse site. These components of water and energy supply are usually spread around the site, positioned so that supply into the packhouse is as efficient as possible.

Fires are most likely to break out in carton stores. Carton erection machines are usually found inside the carton store. The combination of cardboard dust, machinery, and hot glue increases the fire risk, and the cartons stored in this area will cause a small fire to spread rapidly. Ideally, the carton store should be in a separate building from the main packhouse, so that a fire that originates in this area can be contained. If the carton store is attached to the main building, there should be firewalls and fireproof doors between the two buildings to contain a fire.

Staff areas include the administration office space, the staff canteen, and ablutions. The operational management offices are usually inside the packhouse and overlook the packlines. However, administrative staff require additional office space. These offices are usually attached to the packhouse building, but isolated from the noisy production area. Staff canteens and ablution facilities also include the staff locker rooms. Depending on the number of staff members, these can take up considerable space on the site. There should also be a training facility on site, and it is a good idea to design the staff canteen so that it can be used for training during the off season.

Each of these functional areas should be designed, from the outset, so that they can be expanded over time, without compromising efficiency or movement patterns on the site, and without resulting in functions being divided, such as having one part of the administration office away from the rest.

It is important to study the movement patterns on the site and to use this information to find the best place for the functional areas. For instance, it is inadvisable to have forklifts crossing roads carrying truck traffic, or for workers to cross areas with heavy forklift activity to get to their facilities. A further consideration is how packhouse workers will get to work every day. If they are being transported, there should be clarity on whether the vehicles are allowed to enter the site or whether workers will disembark outside the gates. If transport vehicles enter the site, this must be included in the movement patterns.

Before starting the site layout design, it is essential to conduct a geotechnical study on the site, so that the substrate of the land is known. This can have a significant impact

on the earthworks that may be required in preparation for construction, and can even impact on where certain functional areas can be placed. Water flow during high rainfall periods and storm water drainage must also be considered in the placement of functional areas, especially in regions with a high incidence of thunderstorm activity.

Packhouse Production Area

The packhouse production area is enclosed in the packhouse building, although the tip is still found outside the building in most packhouses. The packhouse building must be well-ventilated and have sufficient lighting so that workers can comfortably see what they are doing.

The packhouse production area contains the packlines. In other modules in this series we look at the packhouse process in detail, and discuss the equipment and machinery used at every stage of the process. In summary, a packline typically looks something like this, although not necessarily in this order: wet or dry tip, pre-sorting, pony sizer, washing system, main sorting, fungicide and wax treatments, final sorting, automated grading and sizing, packing, palletisation.

Designing a packline requires specialised skills. The designer considers the citrus types and cultivars that will be packed at the packhouse, the production curves for each type and the combined production curves, the capacity and throughput calculations, the capacity of the machinery and equipment that is available on the market, and many other factors.

The designer also has to look at the latest developments in packhouse technology, and weigh up the cost of adopting new technology versus gains, such as increased efficiency, greater consistency, and cost savings over the operational lifespan of the packline. In the last section of this module we will discuss considerations regarding packhouse automation in more detail.

Packlines must be designed, from the start, so that they are flexible and can be expanded, especially in the automated grading and packing sections. If the packhouse is being built in phases, the designer can go as far as already building the framework for expanding the grading lines at the beginning so that capacity can be increased as needed. Growing volumes is not the only reason why additional packline capacity may be needed. Packlines may also have to respond to more complex market requirements, such as packing the same grade and size fruit in different cartons, which requires more drops from the grading line for the same fruit to accommodate different packing configurations.

There is a wide range of packhouse equipment and machinery manufacturers to choose from, and deciding which system and equipment to purchase is one of the most crucial decisions in packhouse planning. This decision will not only have a massive impact on the establishment costs of the packhouse, but affect operations for the lifespan of the packline.

Some of the factors that play a role in this decision are the track-record of the manufacturers, the after-sales service and availability of technicians in the vicinity, the user-friendliness of the software systems that operate the machinery and, of course, the cost. Choosing a make of machinery that is already widely used in the area around the packhouse is advisable, because the after-sales service is likely to be better, and software systems are more likely to have been adopted for local use.

Most packhouses have a suspended walkway above the production area that allows people to move through the packhouse safely and quickly, and that gives workers, such as sorters, access to their workstations. These walkways usually connect to the

packhouse management and control offices, which usually overlook the packhouse floor. Supervisors and quality control workers also move along the walkways to observe and supervise the work on the packhouse floor, and the walkway is also designed to provide easy access to machinery and equipment for maintenance and cleaning, and to treatment systems for monitoring purposes.

Packhouse Employment

The daily volumes that will be handled determine the number of shifts needed per day. Some large packhouses can have up to 600 workers on site at any given time during peak season, depending on the capacity and throughput, the number of shifts, and the level of automation.

Packhouse workers, such as graders, packers, and palletisers, are usually seasonal workers. Other jobs in the packhouse, such as packline managers, machine operators, system controllers, quality control officers, artisans, and forklift operators, are more likely to be permanent positions. Even if these staff members are not needed during the off season, the packhouse may choose to employ them permanently and carry the cost of their salaries through the off season to secure their services for the next season. These skills are scarce, especially in rural areas, and these staff members are critical to packhouse operations. It is also likely that, at most times during the season, staff members of service providers, such as inspection services, maintenance providers and exporters, will be onsite at the packhouse, requiring additional workspace and facilities.

Assessing the availability of a workforce in the vicinity of a new packhouse is an important part of packhouse planning. If a sufficient workforce is not available, provision must be made for transporting and possibly accommodating temporary workers during the season. If the packhouse is located far from a residential area, it may also be necessary to make provision for accommodating permanent staff year-round. This can have significant implications for costs as well as water and electricity supply.

Packhouse Automation

If efficiency, consistency and cost-effectiveness are the three factors on which decisions around packhouse design are based, then the choice of whether to use automation in the packhouse is clear. Automation comes with a price tag, but the benefits of introducing it outweigh the costs in most scenarios. Let's look at a few specific examples to illustrate this point.

This rail system for empty bins with the robotic bin stacker was introduced in this packhouse to solve a design challenge. The location of the tipper meant that to get empty bins to the bin washer, they would have had to be moved by forklifts across the receiving area, or stacked and kept in the receiving area until being moved outside, which would have meant extending the receiving area. Floor space is expensive, especially if it is under roof, and the better solution in this case was using airspace, which is cheap and unused. The railing system moves empty bins from the tipper to outside the receiving area. The challenge of how to get the bins back to floor level was solved by using this robotic bin stacker and elevator system. When this packhouse runs at full capacity, more than a hundred bins will be moved along this railing system every hour. No manual system would have been able to handle this throughput.

In this packhouse every bin is drenched when it is received, unless it is processed straightaway. The automated drench system allows the packhouse to drench many bins efficiently, and to get consistent treatment of all the fruit in each bin. The system first

washes the outside of the bin so that mud and dirt is not carried into the drenching solution, and then moves the bins along a railing system through the drench.

The drench is coupled with an automatic dosing system, which can also be used with fungicide flooders in the packline. The dosing system adds a small amount of treatment chemicals to the drench solution after each bin, so that the concentrations in the drench solution remain constant, and the treatment chemicals applied to the fruit is consistent.

Using automated grading systems, such as this one, has become mandatory for modern packhouses. Market requirements are becoming more complex, and no human eye can distinguish between the fine gradations in fruit quality that are now required. The efficiency and throughput of automated grading systems is also why this form of automation was the first to be adopted in many packhouses.

Another automated quality control system is this fruit scanner, that uses infrared technology to monitor the sugar and acid levels of the fruit that passes through it, to ensure that these quality factors remain in the range required by the market.

Automated place and jumble packing machines increase packing throughput and efficiency. The machines pack two to three times faster than manual operators, and with greater consistency. The packline manager directs the drops with the highest volumes to the automated packing machines to optimise the benefits of this form of automation. The place packers can handle most citrus types, and pack different counts and carton types.

Automated palletisers are often coupled with automated packing machines, although they can also be used with manual packing. The efficiency and consistency with which this machinery palletise cartons, while maintaining fruit quality, far exceeds the performance of even the best manual palletising systems. Automated palletisers can be set to stack different carton types in the appropriate patterns.

These automated strapping machines ensure that every pallet is secured and strapped properly, consistently, and efficiently.

Automation also offers other benefits: machines can work for longer hours than humans can, they don't make errors due to fatigue or loss of concentration, and aren't subject to disruption due to illness or labour disputes. Guaranteeing consistency, throughput and efficiency in a new generation packhouse requires at least some degree of automation. There will always be a place for people in a new generation packhouse but, as technology advances and becomes a competitive imperative, the skills and job profiles will change to create more opportunities for high-level operational, maintenance and supervisory roles.

Conclusion

In conclusion, in this module we aimed to provide an overview of the importance, benefits, and key factors in planning and designing a new packhouse. It is a highly specialised area and requires professional services and assistance. However, this module should allow you to weigh up your packhouse requirements and understand what the process involves.

Citrus Packhouse

Module 3:
Packhouse Sanitation

Learner Guide

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The content of this module is based on audio-visual material produced by the Citrus Academy.

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Introduction

Packhouse sanitation is critical to preserving the quality and safety of citrus fruit during the packhouse process. Every person working in a packhouse must take responsibility for maintaining a high standard of sanitation to prevent fruit contamination in the packhouse, and especially to prevent fruit from becoming re-contaminated after it has been treated.

Spores and Fruit Infections

In citrus packhouses, spores are the major cause of fruit contamination. Spores are reproductive propagules of certain plants, fungi and algae. They are microscopic and cannot be seen with the naked eye – you will only know that they are present in the packhouse when fruit develops infections, and by then it is too late. The only way to prevent spores from building up in the packhouse and infecting fruit is by having an effective sanitation plan.

In citrus packhouses, most infections are fungal and it is therefore those spores that are of concern. Fungal spores are mostly associated with mould, such as green mould, blue mould, and sour rot.

Fungal spores settle on fruit and surfaces in the packhouse. They start growing and multiplying as soon as conditions are warm and humid enough. De-greening rooms, for example, present just such conditions, as do ambient storage areas. Many spores are unable to penetrate the thick citrus rind on their own so they need an injury to begin the decay process. It is important that the packhouse takes great care never to do anything that can cause injuries to the citrus they pack.

As spores start multiplying, they spread to other fruit and surfaces, thereby increasing the spore load in the packhouse and causing more and more infections. Fruit is treated with fungicides to kill spores on the fruit, but the more spores present, the less effective the treatments.

The main aim of packhouse sanitation is to keep the spore load in the packhouse as low as possible, by not allowing infected fruit into the packhouse, by immediately removing and destroying infected fruit, and by keeping the equipment and work area sanitary. Extractor fans and canopies can also be positioned in the packhouse for optimal airflow to reduce spore load.

Pre-Sorting

Preventing infected and decayed fruit from entering the packhouse is the first packhouse sanitation action. In de-greening rooms fungal diseases develop faster because of the warm, humid conditions. There is often decayed fruit in bins coming out of de-greening rooms, and there might also be decayed and infected fruit in bins coming from the orchard. This infected fruit is referred to as "green bombs" because they cause an explosion of infection in the packhouse if they are allowed inside. They must be removed during pre-sorting, preferably before the fruit enters the washing system. Even though the fruit washing system contains a sanitiser, green bombs will contaminate the water and the rollers and brushes due to the massive spore overload, thereby infecting the system itself.

The golden rule is: if it is not going to be exported, it must not be in the packhouse. Pre-sorting procedures are discussed in greater detail in module 4, which deals with receiving and initial processes.

Sometimes severely contaminated fruit is missed during pre-sorting. If such a fruit is found on the grading line, in a packing bin, or anywhere else in the packhouse, immediately remove the fruit, report it to the supervisor, disinfect the area and equipment and, at the first available opportunity, clean and sanitise the line.

Removal of Fruit

Infected fruit removed during sorting, grading or anywhere else on the packline must not stay inside the packhouse. Remember that fungal spores are spread through the air, the water, and even by vinegar flies. Even if infected fruit is left for only a short period of time, it can spread infections and increase the spore load in the packhouse. All such fruit, along with any fruit that has fallen on the floor or has been discarded for any other reason, must be removed from the packhouse as soon as possible.

Fruit that is destined for the local market or processing should preferably be stored outside the export packing area, especially if the fruit has been treated with fungicides, as active spores on these fruit are likely to be resistant to those fungicides. Infected fruit that cannot be sold on any market must be destroyed away from the packhouse, either by being finely chopped up and spread out in the sun to dry, or by being buried. Waste fruit can also be used for animal feed.

It is best not to store export fruit in the packhouse for too long after being packed, especially in hot conditions – remember that many postharvest diseases develop faster at higher temperatures. Either pre-cool export fruit at the packhouse immediately to stop the development of diseases, or dispatch it to pre-cooling facilities.

Equipment and Workspace Sanitation

The next essential action in packhouse sanitation is keeping the workspaces and equipment in the packhouse clean and sanitary. Remember that you cannot sanitise a dirty surface, so this is a two-step process – wash, and then sanitise. There are three important things here: the sanitising agents that are used, the method of application, and the frequency of application.

Sanitising Agents

There are many available products that can be used as sanitising agents in packhouses. It is important that the product chosen is used correctly according to the manufacturers specifications, that the product is effective against spores, and that the product does not leave a residue that is restricted by the target market.

Chlorine is commonly used for sanitising, but it is important to use the right chlorine products. Swimming pool products are not suitable for sanitising in packhouses – they are formulated specifically for swimming pools, with UV stabilisers, granulators, and slow release of the active ingredient, and should never be used with fresh fruit.

New sanitising products and innovations are often introduced to the market, and many promises are made by its manufacturers. It is important to look critically at new products and to ask questions about them. Efficacy, long term impact, and costs are just some of the factors that should be taken into account.

CRI is constantly researching existing and new sanitising products, looking objectively at various factors, such as short term viability and long term effects. They publish details of recommended sanitising agents, and update these regularly. It is best to use

only recommended products and at the recommended concentrations. CRI is objective in its research and always presents its findings without favouring any commercial entity.

Use the following principles when deciding which sanitising agent to use:

- The product should have the right active ingredients;
- The product should be registered by the South African Registrar and approved by CRI;
- The product must be effective;
- The product must be food grade; and
- The product should not be overly corrosive and cause damage to equipment or surfaces.

Even the safest, most highly recommended sanitising agent can be rendered ineffective, on the one end of the scale, or toxic on the other end, if used in the wrong concentration. The concentration of the active ingredient must be managed very carefully when mixing a cleaning solution to ensure effective sanitation. Always follow the manufacturer's recommendations for each specific product, as the volume of active ingredients can be different between products.

Cleaning and Sanitising Methods

It is important to clean all equipment and work areas thoroughly. Cleaning solution must be applied to all surfaces in the packhouse, including the floors and the walls, and especially surfaces that come into contact with fruit, such as grading tables, brushes, rollers, sizer cups, and packing tables.

The best way of applying cleaning solution is to douse equipment using knapsack sprayers, and to wipe down surfaces with a clean cloth dipped in the solution. Follow the manufacturer's recommendations for the concentration and contact time of the solution on surfaces.

Scheduling

It is important to sanitise the packhouse regularly. Sanitisation costs time and money, and it should therefore be done efficiently and effectively, but neglecting to do it or skipping scheduled sanitisation, can cost the packhouse much more. Develop a cleaning and sanitising schedule that is widely circulated and ensure that it is implemented.

Other Cleaning and Sanitising Procedures

Automated packlines with optical sorters and graders sometimes have automated cleaning and sanitation programmes. Use these programmes as directed by the manufacturers, and make sure that you use the correct concentration of cleaning agents.

Apart from the machinery, equipment and surfaces in the packhouse, picking bins and trailers must be washed and sanitised after they have been emptied and before they are returned to the orchard. Contaminated bins can easily become a vector for spreading infections from one batch of fruit to the next. Bins can be washed in a specialised bin washer or with high-pressure sprayers, which can also be used for trailers.

Emergency Cleaning Procedures

Preparation and protocols must be in place for emergency cleaning operations. If decayed fruit is found anywhere in the packhouse, the immediate area must be cleaned and sanitised without delay to ensure that spores are eliminated. There may also be accidents, such as chemical spills, that require emergency cleaning.

Microbiological Laboratory Testing

It is best practice to engage professional laboratory services to test for microbes and pathogens in the packhouse environment on a regular basis. These laboratories can perform any number of tests at points along the packline to determine the spore load, presence of harmful pathogens, and the risk of infection.

The tests include taking samples of the treatment solutions from the washing systems and the fungicide treatment system, and taking swabs at points along the packline that fruit regularly comes into contact with, such as conveyor belts, sorting tables, grading lines, and packing tables. The spore load in the air is determined by using settle plates, which are left in place for a minimum of 10 minutes before being collected for analysis.

Apart from giving the packhouse management an accurate assessment of the spore load in the packhouse and the risk of contamination, microbial analysis is also a useful tool to measure and monitor the overall sanitation and hygiene of the packhouse environment.

Personal Hygiene

Good personal hygiene practices are part of an effective packhouse sanitation strategy. Every person working in a packhouse must have short nails and clean hands, and no open sores or injuries. Jewellery, such as rings, watches and necklaces, are not allowed in the packhouse, as jewellery can injure fruit, fall off and land in machinery or on lines, or it can be lost in packed boxes, and be a source of contamination.

Protective clothing must be worn by every person in the packhouse, specifically hair coverings, overalls, and, where necessary, gloves. Visitors must also be issued with jackets and hair coverings. Workers must remove their protective clothing when going on a break. If workers wear their protective clothing during breaks there is a risk of the protective clothing becoming contaminated. Protective clothing should be kept clean and well-maintained. It is best to have laundry facilities available in the packhouse for this purpose.

Notices should be posted in locker rooms and bathrooms to remind workers to maintain their personal hygiene, and especially to wash their hands regularly. Check all workers before they are allowed in the packhouse to ensure that they adhere to these practices.

Recordkeeping

Recordkeeping is essential in managing packhouse sanitation. Records should show the frequency of cleaning, the sanitising products used, and the concentrations of those products in the cleaning solutions. Keep records of personal hygiene inspections, and any emergency or unscheduled cleaning that takes place. Records should also include feedback from pre-sorting to enable feedback to the farm.

Citrus Packhouse

Module 4: Receiving and Initial Processes

Learner Guide

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citrus research international

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1st edition 2022

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Visual material production:
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Introduction

Fruit arrives at the packhouse from the orchard in picking bins or trailers, covered in dust, warm from the sun, and with all sizes and sorts mixed together. The only thing you can know for sure is that the citrus fruit in each bin or trailer is the same type and cultivar, and has been picked in the same orchard.

It is the responsibility of the packhouse to clean the fruit, de-green them if necessary, treat them with fungicides to kill established disease, improve their appearance and shelf-life by applying wax, separate them into size and quality categories, and then to pack like fruit together in boxes, ready to be loaded and taken to the harbour for export.

The first step in this process is to receive the fruit at the packhouse and, if necessary, to store it until it can be processed. If fruit is not processed straight away, and especially if it is going to be de-greened, it is drenched to protect against decay. If required, fruit is now de-greened to improve its colour. Right before it enters the packhouse process, the fruit is weighed and the details of the delivery are recorded. Fruit is also pre-sorted to remove green bombs and finally washed, at which point it enters the packhouse.

Receiving

As we have mentioned, fruit is delivered to the packhouse in picking bins or in picking trailers. Bins can be stacked on the back of flatbed trucks, or transported on specialised trailers attached to tractors. On arrival at the packhouse, bins are stacked in storage areas, where a first-in/first-out system is used to make sure that the fruit that was received first is processed first. Sometimes the packhouse is not that busy, and the fruit is processed right away. Trailers are simply unhitched from tractors and left to wait their turn, out of direct sunlight.

If fruit has to be stored for an extended period, such as over a weekend, it is best to store bins in closed storage areas. This fruit should be drenched to protect them from decay even if they are not going to be de-greened.

Weighing

Before fruit enters the packhouse process, the weight of the fruit in each bin or trailer is determined and recorded, along with the delivery date, the PUC of the production unit, the orchard and block number, the type and cultivar of the fruit, and any other relevant information. To enable traceability, it is a good idea to assign a batch number to each delivery which follows the fruit through the packhouse.

The manner in which the fruit is weighed, and the equipment that is used to do this, varies between packhouses, and depends on whether the fruit is in bins or trailers. At some packhouses, individual bins are placed on large scales and the details of the bin and its weight are recorded on the system right before the bin goes into the tipper. In other cases, the details of the bin are recorded on the system but it is only weighed right before it is tipped by scales that are integrated in the tipper system.

Picking trailers have to be weighed on a weighbridge, but few packhouses have weighbridges on the premises. Those packhouses often use an average, weighing ten or twenty trailers at a nearby weighbridge when they start picking a new cultivar, and using the average weight for all the trailers of that cultivar. Best practice is however to weigh every individual trailer and record the exact weight.

Packhouse Delivery Inspection

If the fruit is destined for a phytosanitary market, it has to be inspected at this point for false codling moth and fruit fly infestation. This inspection is part of the management system developed by CRI, aimed at eliminating the risk of FCM and fruit fly infestation of export fruit. For more details on these inspections, please watch the Citrus Academy audio-visual module on Monitoring and Inspection for Phytosanitary Markets.

Drench

The purpose of the drench is to remove the field heat from the fruit, and to protect the fruit from decay during de-greening and storage. All fruit that has to be de-greened is drenched before going into the de-greening rooms. Fruit that is going to spend an extended period stacked in storage waiting to be processed must also be drenched to protect it against decay. Some packhouses go as far as drenching all fruit that is not going to be packed within a few hours after arriving at the packhouse. This practice has a significant impact on reducing fruit decay and assuring quality.

There are different kinds of drench systems, but the most common involves stacking fruit bins two high in a drench with side covers, and flooding the fruit with water containing treatment chemicals. If the fruit is in trailers, it is first tipped and the fruit that has to be de-greened is sorted out and collected into bins to be drenched. Note that it is best practice not to stack bins more than two high, otherwise one will not get sufficient coverage of the treatment chemicals on all the fruit, particularly those in the bottom bins. The drench solution is recycled constantly, and replaced after a certain number of bins. The size of the drench tanks determines how many tons of fruit can be treated before replacing the solution.

Generally, fungicides, a water sanitiser and 2.4-D are used in the drench. 2.4-D helps to prevent the calyx from abscising. CRI issues and updates recommendations for the drench mix on a regular basis, and it is advisable to follow these recommendations closely. These include recommendations for the chemicals used in the drench, the mixing protocol and the drench operation. Be aware of the residue thresholds for your export markets and make sure that they are not exceeded.

Coverage and contact time are the crucial factors in the drench to ensure maximum benefit. Make sure that these recommendations are strictly adhered to for every batch of fruit. After drenching the fruit, it must be allowed to dry completely before going into the de-greening rooms. Ethylene gas cannot penetrate through moisture, and if fruit is still wet, it will take much longer to de-green.

De-greening

Citrus fruit reaches maturity in the winter months, between February and September, depending on the type of citrus and the cultivar, and the production region. The fruit rind changing colour is one of the last stages of the physiological maturing process, and it is possible for fruit to have matured internally, meaning they have reached the minimum sugar and acid levels the market requires, but not yet to have developed external colour. Growers are keen to start picking and packing their fruit as soon as they can to get into the market as early as possible.

De-greening is a treatment that accelerates the rind colour development by exposing fruit to ethylene in special rooms in the packhouse. Ethylene is a natural hormone that is associated

with cellular processes involved in ripening, such as the breakdown of acids and rind colour development. Ethylene specifically breaks down the green chlorophyll pigments in the flavedo, and induces orange carotene pigments to be synthesised more quickly.

Many types of citrus, including lemons, grapefruit, oranges, and tangerines, can be de-greened, but it is important to remember that fruit should only be de-greened after colour-break, meaning that natural colour development has to have started for de-greening to work. The temperature, ethylene concentration and exposure time are the critical factors for de-greening. Typically, fruit is exposed to between one and three parts per million ethylene gas for one to three days, at a temperature of between 18°C and 25°C. These factors vary for each type of citrus and cultivar, and depends on the colour of the fruit going into the de-greening rooms. Relative humidity and carbon dioxide levels inside de-greening rooms must also be managed rigorously.

The temperature, ethylene concentration, carbon dioxide levels, and relative humidity in de-greening rooms are monitored by sensors inside the rooms. The levels can be adjusted manually or electronically, with the most advanced systems monitoring and automatically adjusting the levels according to programmed set points.

Pre-Sorting

Before fruit enters the packhouse process, it is essential to remove green bombs and fruit that is clearly not suitable for export. Green bombs, which are fruit that is badly infected with fungal pathogens, will contaminate the systems and other fruit, and increase the spore load in the packhouse. Processing and treating fruit clearly not suitable for export beyond this point is a waste of time and money.

Pre-sorters remove all fruit that is decayed, split or clearly not suitable for export. They can also remove fruit that is too large or too small for export, but a pony sizer can also be used for this purpose. Decayed and split fruit is removed and destroyed – please see the module on Packhouse Sanitation for more details – and other fruit can be redirected to the local market lines or processing bins.

Fruit Washing

Fruit enters the packhouse through a wet or dry tip. Fruit is washed with water containing a sanitiser, in order to kill fungal spores, and to remove organic material and dirt that may have collected on it in the orchard and during picking and transport.

Sanitisers

Chlorine is a popular sanitiser in washing systems. The efficacy of chlorine however depends on the pH of the water, and on how clean the solution is. Chlorine is three times more effective in water with pH7 than pH8, and it is most effective if used in water with a pH between 6.5 and 7.5. If the pH of the water is outside this range, it should be corrected before being used in the washing system. If the sanitising solution in the washer becomes dirty, the chlorine will bind with the dirt particles in the water and become less effective at sanitising the fruit.

It is also important to keep in mind that chlorine breaks down Imazalil, one of the most important postharvest fungicides, and it will compromise the efficacy of the fungicide treatment if still present. Therefore, effective drying of the fruit before the fungicide bath is important.

Chlorine, or calcium hypochlorite products that have been formulated for swimming pools should never be used in a packhouse. Chlorine is volatile, and the formulations meant for use in a packhouse quickly dissipate after doing its job and sanitising the water. Swimming pool products are formulated so that the chlorine is released over a longer period to extend its sanitising action. Such a formulation gives enough active concentration in clear swimming pool environments, but the active concentration at any given time is much too low for our application. Furthermore, swimming pool formulations contain UV stabilisers and flow agents, creating a risk of unwanted residues on fruit.

Peracetic acid, or PAA, products are also used as sanitisers in washing systems, and are becoming more popular. It is important to consult CRI recommendations, and to follow the manufacturer's instructions closely for the correct concentration and application methods. Ozone is another sanitiser that is becoming more popular, and is applied to washed fruit by specialised systems.

When new sanitising products come onto the market, they have to be registered under the National Regulator for Compulsory Specifications Act (Act 5 of 2015). As part of the registration, the efficacy, possible side effects, residues, and the effects of long-term use must be verified. These findings are available from the manufacturer, and CRI can be consulted to be sure the product is suitable for use in a citrus packhouse. Remember, CRI act in the interests of the citrus industry alone.

Tip Systems

Fruit enters the packline through a dry or wet tip system. In a dry tip system, fruit is gently let out of bins onto a conveyor. In a wet tip, the fruit is tipped into a bath or tank of water. The water is agitated using, for instance, water jets at one end, so that the fruit moves through the bath. The fruit moves out of the bath on an elevator system and onto a conveyor.

The fruit then moves through a washing system with rollers and brushes. The sanitising solution is in a reservoir below the washing system from where it is sprayed through nozzles onto the fruit. The fruit is scrubbed clean of scale insects and dirt by the brushes.

The concentration of the sanitiser in the washing system should be checked regularly, and the sanitising solution should be filtered, and replaced regularly to ensure that it remains clean and effective. Spores, dirt and debris can build up in the system through the day, and this can form biofilm in the pipes and around the inside walls of the water reservoirs. Biofilm is an accumulation of fungi and bacteria, and can lead to the whole system becoming contaminated. At the end of each day, water reservoirs should be drained and washed with clean water.

Conclusion

If we have followed protocols and best practice, at this point of the packhouse process we will have fruit that is de-greened, healthy, clean and likely to be exported. In the next module, we look at how fruit is treated with fungicides and waxed in preparation for being packed.

Citrus Packhouse

Module 5:
Fruit Treatments

Learner Guide

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Introduction

After fruit has been washed on entering the packhouse, they are ready to be treated with fungicides and have wax applied in preparation for packing.

Fungicide Treatment

Blue mould and green mould are two of the most economically significant postharvest diseases in citrus. These are fungal diseases and they infect fruit through spores. Sour rot is another serious fungal disease that is responsible for significant postharvest losses, and can spread in packed boxes.

Fungicides

Fungicides used in packhouses are aimed at controlling these significant fungal diseases. CRI publishes and regularly updates information about the registered active ingredients. On this fact sheet, you will find the name of the active ingredient and its formulation, the FRAC code, the target disease, the dosage and parts per million concentration.

CRI also publishes a protocol for fungicide treatments, updating it regularly with the latest research findings. It is critical to adhere to these recommendations. Fungicides must always be used as per their registrations, taking into account the residue levels allowed by the target market. Following the recommendation and protocols from CRI and your target market will ensure that the packhouse is compliant.

The fungicide treatment leaves a residue on fruit which protects the fruit in transit to the overseas market. If the residue is too low, the fruit will not have proper protection. If the residue is too high, the fruit may be rejected because the Maximum Residue Levels, or MRLs, of the target market will be exceeded. The residue that is loaded on fruit depends on three main factors in combination, namely the temperature of the fungicide solution, the contact time, and the fungicide concentrations. Sometimes the pH of the solution also plays a role.

In most cases, a fungicide solution at a higher temperature not only makes the fungicide treatment more effective, but also helps the water evaporate faster after the treatment, so that the fruit dries faster. A higher temperature also improves the uptake of the fungicide into fruit injuries. The optimal contact time depends on the temperature of the solution, the pH of the water, and the citrus type and cultivar. Best practice is to follow the recommendations on the CRI fact sheets. It is also important to know the maximum temperatures to use. If the fungicide solution is too hot, it can damage the fruit rind and can cause a too high fungicide residue on the fruit, possibly exceeding the MRL of the target market.

Fungicide Treatment Systems

Two systems can be used in packhouses for fungicide treatments, namely a fungicide bath or a flooder, also called an in-line drench.

Fruit is moved into the fungicide bath on a conveyor belt, and moved through the bath at a specific rate that ensures sufficient contact time to leave the required residue. It is important for fruit to be clean and dry when it goes into the fungicide bath, otherwise the fungicide solution will become dirty sooner and will have to be replaced more

often. In addition, it minimises the risk of transferring sanitising agents into the fungicide bath, with chlorine being of particular concern.

In a flooder, or in-line drench, the fruit is moved through curtains of fungicide solution that drenches the fruit, using brushes that continuously rotate the fruit. The number of curtains, the volume of fungicide solution that falls in each curtain, the temperature of the water, and the rate at which the fruit moves through the flooder are calculated to ensure sufficient coverage and contact time. The fungicide solution is in a reservoir from where it is pumped through the flooder. The reservoir can be part of the flooder, or free-standing. After the flooder, the fruit moves over rollers and doughnut sponges under fans that remove excess moisture.

It is somewhat easier to manage the pH, temperature, exposure time and fungicide concentration in flooders than in baths. They are also smaller and more energy and water efficient, with flooder tanks being roughly a third of the volume of a bath for the same size system. Fruit will also not be left in the fungicide solution for too long should the packline stop for some reason, such as a power outage.

The concentration of fungicides in the fungicide solution used in a bath or flooder must be monitored and controlled to ensure that the treatment remains consistently effective for every batch of fruit. The solution can be topped up with fungicides either manually or by using automated, integrated dosers. A manual top-up procedure is based on the volume of fungicide solution that is used, the required concentration of fungicides, and the amount of fruit that moves through the bath.

The pH of the water used in the fungicide solution has a significant impact on the efficacy of the fungicides in the solution. Some systems also have integrated pH monitors, which check, and can even correct, the pH of the fungicide solution on an ongoing basis.

It is important not to rely simply on procedures or automated systems to maintain the correct fungicide concentrations and pH. These factors must be measured and recorded regularly as part of packing process quality control. Titration is the most convenient way to accurately determine the concentration of Imazalil in the fungicide solution. Best practice is to titrate a sample from the fungicide solution in the bath or fungicide tank every second hour, and to measure the pH of the solution at the same time. Titration is discussed in detail in the next section. The findings from these tests are recorded, and corrective action is immediately implemented if the values are outside the set parameters. For accurate information on all the fungicides used, and for audit purposes, fruit samples have to be sent to diagnostic laboratories for residue testing.

Fungicide Titration and pH Measurement

The principle of titration is based on determining the concentration of one substance by adding another substance in small increments. The two substances react to each other in a specific way and, because we can measure how much of the second substance we needed to add in order to get a specific reaction, we can calculate the concentration of the other substance.

In the case of a fungicide such as Imazalil, the concentration of the fungicide is determined by titrating the solution with a known volume of a standard solution, then using an indicator to observe a colour change. This colour change, or end-point, enables us to determine the concentration of the fungicide.

If the fungicide solution contains only one fungicide, such as Imazalil, it is easy to determine the concentration by using titration. If there is more than one fungicide in

the bath it becomes more challenging, but special methods have been developed to do this. For the purpose of this module, we will do Imazalil titration as an example. Please consult your agrochemical supplier or CRI for instructions on other and more complex titration procedures.

For Imazalil titration, the following equipment is essential: a 25ml burette with 0.02ml gradation with a burette stand, a 250ml Erlenmeyer flask, an indicator dropper bottle, and flasks, cylinders or a pipette for measuring chemicals. The chemicals used for Imazalil titration are sulphuric acid, dichloromethane, an indophenol blue solution, and a reasonably fresh sodium lauryl sulphate. All solutions must be kept free of any contamination.

A sample is taken of the fungicide solution, either from the fungicide bath, or from the flooder reservoir. Carefully mark samples, noting the date and time. If there is more than one line in the packhouse, carefully mark where the sample was taken.

Before doing titration, first measure the pH of the solution, using an electronic pH meter. Record the pH along with the time and date.

Place 25ml of the fungicide solution sample in the Erlenmeyer flask. Add 10ml sulphuric acid and mix well. Then add 25ml of dichloromethane and again mix well. Add ten to fifteen drops of the indicator indophenol blue, until the solution turns blue.

The solution in the Erlenmeyer flask is now titrated using sodium lauryl sulphate. Ensure that the burette is filled with precisely 25ml sodium lauryl sulphate and secure it in its stand. Using the valve at the bottom, add the sodium lauryl sulphate drop by drop, gently swirling the solution continuously. Keep adding drops, swirling the solution, until the solution turns colourless. This is called the endpoint.

Record the volume of sodium lauryl sulphate used. Beware of making a parallax error. This volume is now used in the standard formula to calculate the Imazalil concentration in parts per million, or ppm. Consult your agrochemical supplier about the formula to use for your fungicide product. Record the results of the calculation along with the pH. Indicate what corrective actions should be taken.

Titration is not exact, and the result is subject to a 25% correction factor, which is the international standard. Therefore, if the result is 500 parts per million, it may in truth be as low as 375 or as high as 625 parts per million. For more accurate information, diagnostic laboratory tests are required.

Wax Treatment

After the fungicide application, the fruit goes through a drying tunnel. Once the fruit has been dried, wax is applied to the fruit. Wax helps to limit moisture loss from the rind, thereby extending the shelf-life of the fruit, improving the appearance of the fruit, and helping to protect the fruit against cold damage. Fungicides can also be mixed with the wax, providing another control point for fungal spores and assisting with resistance management.

Market requirements determine what type of wax is applied to the fruit, if any at all. There are different types of citrus packing waxes of which the most common are oxidised polyethylene waxes and natural waxes. Carnauba wax is extracted from palm trees and classified as a natural wax.

Citrus packing wax products are water-based, and are carefully formulated, with a very exact combination of components, some of which are volatile. Fruit coating products consist mainly of the wax itself, emulsifiers, plasticisers and drying agents. The emulsifier interacts with the

wax that is naturally on the fruit, emulsifying it with the packing wax to form a thin film on the fruit. Plasticisers ensures that the wax film remains pliant and does not crack.

It is essential to ensure that the wax remains tightly sealed in its containers until it is used. If the wax is exposed to air, the volatiles will dissipate, making the wax less effective. It is also important to constantly agitate the wax at a low speed while it is being applied to make sure that the components are evenly mixed, especially if a fungicide is added to the wax.

Wax is applied in most packhouses by automated applicators, with the fruit moving along at a set speed over brushes that constantly rotate them. The wax is sprayed onto the fruit by nozzles from above. Sensors before the wax applicators detect the number of fruit moving under the nozzles, and determine how often the nozzles must spray wax to properly cover all the fruit. Ensure that the wax manufacturer's instructions are followed rigorously.

It is important that the fruit is free of water droplets before going into the wax treatment. If the fruit is very slightly damp, it will actually help with spreading the packing wax into an even, thin film, but if there are visible water droplets, meaning if the fruit is wet, it will change the combination of the wax components and compromise its efficacy.

It is essential to maintain the brushes in the wax applicator. If the brushes are not thoroughly cleaned and maintained, the bristles become stiff with hard, clumped ends. This can easily cause fruit injuries, increasing the risk of infection and leading to cracks in the wax coating, which will compromise fruit quality. Wash the bristles every day with water and a residue-free, fruit-grade soap. Although it can be a challenge to get the wax out of the bristles, there are excellent products for this purpose, and it should not be neglected.

After the wax has been applied, the fruit again moves through a drying tunnel. Drying must not be too hot or for too long, as this can break down the wax and lead to tacky and sticky fruit.

Fungicide Resistance

In a given population of fungal spores that have not been exposed to an appropriate fungicide before, most of the individual spores will be sensitive to the fungicide and will be killed on contact. However, due to natural genetic mutation and simply natural genetic variation, there will be a small percentage of spores that are resistant to a particular fungicide. The level of resistance varies, from spores with a resistance level only slightly higher than the general population, to a very small number of spores with a very high resistance level.

If fungicide treatments in the packhouse are not done properly, it allows for more and more of these resistant spores to survive the treatment, even those with marginal resistance. These spores can give rise to spore populations with much higher levels of natural resistance to fungicides.

The arsenal of fungicides at the disposal of the citrus industry is quite limited, and losing even one of them because of resistance can have catastrophic consequences. Increasing fungicide resistance, mostly because of poor fungicide application practices in packhouses, has been identified as a significant threat to the sustainability of the citrus industry in South Africa.

Managing fungicide resistance depends on getting the optimal fungicide residue on fruit by implementing the best application practices, and on using the best combination of fungicides at the right stage of the packhouse process.

The first factor is the residue that fungicide treatments leave on the fruit. The residue level depends on the temperature of the fungicide solution, the contact time, and the

concentrations of the fungicides. If the treatment is optimal, the residue on the fruit will control all fungal spores, even those with some level of resistance. If the residue level is too low, more resistant spores will survive and multiply.

The second factor is how available fungicides are combined and used at different stages of the packing process. The first rule is to use a particular fungicide at only one point in the packhouse. Fungicides can be applied at three different stages of the packhouse process, being in the drench before de-greening, in the fungicide bath or flooder, and mixed with the wax. If a fungicide was used in the drench, that same fungicide must not be used again later, for instance in the fungicide bath or flooder. It will simply not be effective against spores that survived the first treatment, and greatly increases the risk of resistance developing.

Best practice is to use a combination of fungicides, which are able to attack fungal spores from many different directions. To enable us to do this, we need to know which fungicides can be used together, and to which ones the same spores are likely to be resistant.

FRAC codes were developed for this purpose. It can be found on the fungicide label, and is also noted on CRI's fact sheet. The FRAC code is assigned by the Fungicide Resistance Action Committee, to group together active ingredients which demonstrate potential for cross resistance. It is an easy way to know which fungicides to use together – as long as you are combining fungicides from different FRAC groups, you are safe.

Conclusion

The fruit is now ready to be separated into grade and size categories, which is the last step before the fruit is packed for export. In the next module we will look at grading and sorting practices.

Citrus Packhouse

Module 6:
Sorting and Grading

Learner Guide

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1st edition 2022

The content of this module is based on audio-visual material produced by the Citrus Academy.

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Introduction

Fruit is marketed and exported from South Africa in two formats. By far the largest volume of fruit is exported in cartons and is meant for fresh consumption. The second format is when processing fruit is exported in bulk bins to overseas juice factories.

Fruit that is meant for fresh consumption is exported in cartons. All the fruit in every carton is the same type and cultivar, as well as the same grade and size, within very narrow tolerances. This means that the contents of each packed carton of export citrus is homogenous. This information about fruit in each carton is printed on a label that is attached to the outside of the carton. Cartons are in turn stacked and secured on pallets, with all the cartons on a pallet containing fruit of the same type, cultivar, grade and size.

The grade of the fruit is also referred to as the fruit class, and is determined by the quality of the fruit. Very strict parameters, set by regulations and export markets, determine the qualities fruit must have to belong to a certain grade. The higher the grade, the higher the return for the grower.

Up to this point in the packing process, when the fruit has been cleaned and treated, all the fruit that came from the orchard has stayed together through the packing process, with the exception of clearly damaged and decayed fruit that was removed during pre-sorting. It is now time to group them, like with like, in preparation for packing.

The terms sorting and grading are sometimes used interchangeably, but in packhouses they are generally used for two distinct actions, which is how we will use these terms in this module. Sorting is the action of separating out fruit that is not fit for export, and directing this fruit to the local market line, processing fruit bins, or waste fruit bins. This is done by hand. Grading is the action of separating fruit that has passed through sorting into different grades, or classes. During grading, some fruit may still be directed to processing, local market, or waste, but this should be minimal. This is almost always done by automated grading systems. Sizing is the action of separating fruit of a particular grade into size categories, also called counts. Automated grading systems size the fruit at the same time as grading them.

Fruit Quality Factors

If you have some experience in fruit production or packing, you can probably look at two fruit and form an opinion about which one is better quality, especially if you can also cut open and taste the fruit. But how do you do that? What factors are you taking into account? And, more importantly, how does the citrus industry objectively codify fruit quality? After all, a fruit of a particular type, cultivar, grade and size that is produced and packed in the Limpopo province should be very similar to another fruit of that type, cultivar, grade and size that is produced and packed 2,000km away in the Eastern Cape.

To make this possible, firstly we need to know what to measure, then we need to develop a standard protocol for measuring, and lastly we need to agree on the standards for each of these factors for different classes of fruit. Fruit quality factors have been defined to tell us what to measure, and we divide these factors into external and internal fruit quality factors.

External Fruit Quality Factors

External fruit quality factors describe the appearance of the fruit, and mostly have no real impact on the taste or eating quality. Fruit with poor external quality, however, is less desirable, and will fetch a lower price from the consumer.

External quality factors use the Colour Prints for Blemish and Appearance Standards as a measuring tool. The Colour Prints are issued by CRI and contain a set of graded colour prints for each external quality factor for each citrus type and variety. From these the standards for fruit of particular grades are defined. They are used at sorting stations to assist sorters with distinguishing between fruit that meets the minimum export standard and fruit that does not. They are also used in control rooms for automated grading systems, to manage the settings that differentiate between grades of fruit.

Standards are set for a range of external quality factors, which we will look at in turn. We will use the Colour Prints to illustrate the graded standards for each factor. Some external quality factors only apply to particular fruit types, and in some cases separate standards are set for different types. It is, however, important that you are aware of all the external quality factors that are regulated and that you should be paying attention to.

Fruit colour is a very noticeable external quality factor, and the Colour Prints contain sets for each citrus type and many cultivars.

Another external quality factor is damage caused by pests and diseases. This includes damage from insects such as thrips, red scale, rust mite, bollworm, mealybug, and leaf hopper. Pest insects also causes the growth of sooty mould, which is also considered pest damage. Disease damage of significance is caused by citrus black spot and alternaria brown spot. Wind scars, hail damage and frost damage are external quality factors caused by the weather, although frost damage is likely to cause more internal than external damage to fruit. Chemical burns, stem-end browning and oleocellosis are other damage factors that are regulated.

Standards are set for fruit malformations such as sheep nose, high shoulders, flat fruit and protruding navels, as well as skin defects such as rough texture, ribbing, ridging, rind pitting, and peteca.

Internal Fruit Quality Factors

Internal fruit quality factors determine the taste and eating quality of the fruit. There is a separate measurement for each internal fruit quality factor.

Juice content is measured by selecting a sample of fruit, weighing the fruit, extracting all the juice, separating the juice from the pulp, and weighing the fruit rinds and pulp. The juice percentage is then calculated based on these two weight measurements.

Degrees Brix is a measurement of the sugar content of the fruit. It is expressed as °Bx, with one degree Brix meaning one gram of sucrose per hundred grams. Brix is measured with the help of a refractometer.

The percentage acid content of the fruit is determined by titration. A sample of 20ml juice is placed in an Erlenmeyer flask and five drops of phenolphthalein indicator are added. A sodium hydroxide solution is then titrated into the flask, using a burette with precise measurements, until the juice in the flask turns pink, which is when the acid is neutralised. Initially it may be difficult to see the point at which the colour changes, but near the end-point the juice mix slowly lightens in colour, almost becoming clear before going very light green. A few extra drops of the sodium hydroxide will make the solution turn and stay pink. If you go past this point and the solution changes from pink to a deep purple or orange, you have added too much sodium hydroxide and you will need to empty the flask and begin again. Overzealous swirling often leads to passing the end-point. The volume of sodium hydroxide solution that was necessary to neutralise the juice is used to calculate the percentage acid content of the fruit.

The degrees Brix:acid ratio determines the tastiness of the fruit – if the ratio is too low, the fruit will be very sour, and if the ratio is too high, the fruit will taste bland. The ratio is calculated by dividing the degrees Brix, which is the sugar percentage of the fruit, by the acid percentage.

Seediness and granulation are another two internal quality factors that are regulated, as is internal fruit colour for pigmented grapefruit. Standards are also set for over-ripeness, which can also be considered as an internal quality factor.

Export Standards

The Standards and Requirements Regarding Control of the Export of Citrus Fruit document is published every year by the Department of Agriculture, Land Reform and Rural Development, or DALRRD, and empowered by the Agriculture Product Standards Act of 1990. This document sets out the minimum standards for the quality of export citrus fruit, and the requirements for the packing, marking and labelling of the fruit. The Standards and Requirements document describes in great detail the minimum requirements of the colour, blemishes, shape, skin texture and other characteristics of each fruit type that can be exported as different grades, or classes, as they are called in the document. This is the minimum standard that all export fruit must comply with, and the standard PPECB will apply when inspecting fruit.

The Standards and Requirements also set out detailed procedures for measuring internal quality factors, and address aspects for food safety compliance that might apply to citrus specifically, that are not covered in general food safety law, such as labelling that indicates postharvest treatments.

On top of the minimum standard, export markets and specific clients, such as overseas supermarket groups, may set their own standards and requirements to meet the specific demands of their customers. These standards and requirements are negotiated between the export agent on behalf of the grower and packhouse, and the overseas client. Often, they are already agreed upon at the start of the season, and clients are not generally tolerant of deviations from the agreed standards. PPECB does not inspect according to these private standards.

The private standards are usually contained in a packing guide issued by export agents at the start of every season and sent to the producers and packhouses from where they source fruit. The packing guide contains all the information that the packhouse needs, including standards for packing material, place packing diagrams, palletising diagrams, and much more.

CRI's Colour Prints for Blemish and Appearance Standards are used in DALRRD's Standards and Requirements and in the exporters packing guidelines, to indicate the standards for different grades of export citrus.

Packhouses must be able to grade fruit according to the standards and meet the requirements of export markets and overseas clients. To achieve this, it is essential that sorting and grading practices are aligned with market standards, to the finest detail.

Sorting

In most packhouses there are two or three different sorting stations, although sometimes not all of the stations are manned, depending on the quality of the fruit that is running on the line at the time. Sorting teams at the different stations might be looking for different defects in different packhouses. For instance, on some packlines the pre-sorting team may

also be asked to remove outsized fruit or very green fruit, in addition to decayed and split fruit. But in the end, it is important that, between the sorting stations, all fruit not fit for export should be removed.

Sorting Stations

The first sorting station is pre-sorting, directly after the tip, either just before or after the fruit washing system. We discussed pre-sorting in detail in module 4. Pre-sorting teams aim to remove decayed and split fruit, but may also be tasked with removing fruit that has other kinds of defects. Keep in mind though, that if the pre-sorting station is before the washing system, it is not easy to see marks on the fruit clearly because the fruit may still be quite dirty. Pre-sorters must remove decayed and mouldy fruit, which can be recognised easily enough. If these green bombs are allowed to enter the washing system, they can contaminate the system and spread decay.

The second sorting station is either right before or right after the fungicide and wax treatments. In most packhouses, this is referred to as the main sorting station. Main sorting aims to remove fruit that has pest or disease damage, with special attention to false codling moth, fruit fly and black spot infestation symptoms, as well as other fruit that is clearly not fit for export. Colour prints are posted at main sorting stations to assist sorters with identifying the fruit that cannot be exported.

If there is a third, or final, sorting station, it will be right before the automated grading system, or after the system by the packing tables, for a final verification that the fruit that is going onto the packing tables meets the required standard.

Sorters

A good sorter has keen eyesight, is able to concentrate for long periods, knows which fruit goes where, and, above all, knows the export standard. Sorters must keep their nails short and their hands very clean. In some cases, sorters may be required to wear gloves. It is very important that sorters handle fruit with care and prevent any injuries to the fruit. Remember that small fruit injuries that you cannot see with the naked eye can become an infection point and lead to postharvest decay.

When they are recruited, sorters may be required to do a colour blindness test. The ability to see colour and blemishes on fruit is critical to performing this task.

Sorting Tables

Best practice is for sorting tables to be well-lit, preferably with neon lights right above the sorting area, and at a comfortable height, so that sorters do not have to lean forward or work with their hands held too high. They should be of a width that sorters can reach all the fruit on their line without bending forward, and have rollers that continuously rotate the fruit.

Sorting Practices

As the fruit passes by in front of you, look for fruit with defects and blemishes. This may include the following:

- Decayed fruit with green mould, blue mould or sour rot
- Split fruit
- Green fruit

- Fruit with false codling moth or fruit fly sting marks
- Fruit with citrus black spot
- Fruit with other pest damage, such as red scale, bollworm, thrips or mite
- Fruit with sooty mould
- Fruit with oleocellosis
- Fruit with wind damage
- Fruit with long stems or picking injuries

You will have different instructions of what to do if you find fruit with each of the defects. This will depend on the severity of the defect, and on the market standard you are using. For instance, if you find any fruit with symptoms of false codling moth, fruit fly or citrus black spot infestation, you must remove this fruit immediately and send it to the fruit waste bin. Such fruit cannot be sold fresh or sent to the juice factory. The same goes for decayed and split fruit. But certain markets may have tolerance for some wind damage, or some thrips damage, even if the fruit is exported as grade 2 fruit. It is always better to err on the side of the grower, meaning that you should rather let fruit through even when there is a small chance that the fruit can be exported. Only remove fruit that you are absolutely sure cannot be exported.

If you find fruit with picking mistakes, such as fruit with long stems or fruit with picking injuries, you should put the fruit aside and inform your line supervisor, so that they can give feedback to the picking teams. Clip the long stems and put the fruit back on the line, if it has no other defects. Remove fruit with picking injuries because they will decay.

Grading

Grading is now fully automated in most packhouses, although there are still a small number of packhouses where grading is done by hand.

Market standards and requirements have evolved over time, and retailers overseas use these standards to differentiate their offerings to the consumer from those of competitors. In addition, for the same grade of fruit, some export markets may have requirements that differ from the requirements of another export market in small but important details. For instance, because lemons are used in some markets almost exclusively in the hospitality industry, those markets want fruit that is identical to those required by other markets, except that they place value on how long the fruit is because longer fruit gives them more lemon slices per fruit. These markets are also willing to pay a premium for fruit that meets their particular expectations. If a packhouse is able to separate out fruit that meets these requirements, it can be of great benefit to the grower.

This means that a packhouse can no longer afford to only separate fruit into two or three grades. They need to be able to make fine distinctions between fruit, and to separate fruit into categories that meet very specific, and even niche, requirements, in order to optimise returns for the grower.

Manual grading is therefore no longer a viable option for most packhouses, because no human eye can make such fine distinctions at speed. Manual graders are also less consistent than automated grading systems, because they get tired or distracted, and lose concentration.

There is a wide range of automated grading systems. On all of them, fruit is first guided from the conveyor belt into individual cups that run in lines. The fruit runs in these lines

under a bank of cameras, one above each line, which takes a large number of photos of each fruit. These photos are analysed by a computerised system that has been programmed with the standards and tolerances for each size and grade category that is being packed. At the same time, the system measures the size of the fruit.

The system is also programmed with instructions of where to send the fruit in each category. Mostly this instruction will be to drop the fruit onto a line going to a packing table, where fruit of the same size and grade category gathers, ready to be packed by a packer or an automated packing machine. Alternatively, the system can also direct fruit to the local market line, or to the processing fruit line.

Fruit labelling banks can be integrated with the automated grading system, with an instruction to label fruit of particular categories programmed into the system. A number of labelling banks can be installed on a line, and the system will instruct the fruit labellers to apply the right labels to the right fruit.

In the control room, quality control officers can draw samples from the automated grading system. They simply enter the number of fruit in the sample and the category from which the sample must be taken into the system, and the fruit sample is automatically directed to the control room. The quality control officers then examine the fruit in the sample to make sure that the system is grading to the right standard and that the settings are not too strict or too lax.

Sizing

Citrus fruit size categories are more commonly referred to as counts. The count is simply the number of that particular fruit type of that particular size that can fit into an A15C telescopic carton, which is the most common carton that is used for export citrus, and is therefore used as the reference carton for counts. As an example, if a Valencia orange is count 64, it means that 64 Valencia oranges of that size will fit into an A15C carton. If a Valencia orange is count 105, it must be really small, because now 105 of those oranges can fit into an A15C carton.

These are the standard counts and sizes for oranges, soft citrus, grapefruit, and lemons and limes. The diameter measurements that are given here are the average measurements for fruit in that size category, and is used by automated grading systems to size the fruit.

The only mechanical sizers that are still common in packhouses are the pony sizers that can usually be found close to the pre-sorting station. These pony sizers remove fruit that is too small to be exported. Mechanical sizers are seldom used for the main sizing, except maybe on local market lines, or lines on which processing export fruit is sized.

Conclusion

We have now reached the point where fruit unsuitable for export has been removed, the remaining fruit has been cleaned, treated, and then sent through an automated grading system that separated the fruit into groups of the same grade, or class, and size. The fruit is now ready to be packed according to the requirements of the overseas buyer.

Citrus Packhouse

Module 7:
Packing Practices

Learner Guide

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Citrus Growers' Association OF SOUTHERN AFRICA
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1st edition 2022

The content of this module is based on audio-visual material produced by the Citrus Academy.

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Visual material production:
Sagritex (Pty) Ltd

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Introduction

We have reached the stage of the packhouse process where the fruit has been prepared for packing, and grouped together according to size and grade, or class. The next step is to pack the fruit into the right carton, in the correct packing pattern, and with or without labels and wrappers, depending on what the market wants. After this, the carton must be labelled with the correct details, weighed and recorded on the system, and then stacked on a pallet with cartons containing fruit of the same grade and size, packed in the same way in the same cartons, and destined for the same market.

Before we look at how to do these things, we need to learn more about packing material and about packing instructions.

Packing Material

Packing Cartons

The first and most important packing material is the packing carton. Cartons come in many sizes, configurations and colours, but there are only two main kinds of cartons, namely telescopic and open-top display cartons. Before we look at these two kinds, note that carton types are coded, and are generally referred to by this code. The number in the code, such as the 15 in A15C, is the weight of the fruit the carton is designed to carry.

Telescopic cartons consist of two parts, being an inner, into which the fruit is packed, and an outer, or lid, which it is placed over the fruit when the carton is full. The outer is usually printed with branding information. The A15C telescopic carton, at 400x300x270mm, is the most commonly-used carton for export citrus. But apart from the A15C, there are actually not many other telescopic carton sizes that are used. The others for which there are specifications are the A07C at 400x300x150mm, the D15C at 600x400x160mm, the E15C at 600x400x170mm, and the G15C at 600x400x215mm.

Open-top display cartons do not have lids, and they are ready to be packed on shelves in stores without having to be re-packed. Open-top cartons come in a much greater variety of sizes and configurations than telescopic cartons. Fruit is usually packed in one, two or three layers in the carton. These are the open-top display cartons that are used for export citrus.

Both carton types have ventilation holes. The configuration, or pattern, of these holes are the result of thorough research around the flow of air through stacked pallets. In the module dealing with logistics, we discuss in detail the cold chain and its critical role in the success of citrus exports. For now, it is important to note that when pallets of fruit are being stored or transported under refrigeration, cold air is forced through the pallets vertically and horizontally. The ventilation holes in cartons enable cold air to flow into and through the fruit inside cartons to cool them. The holes are designed to line up when cartons are stacked on pallets. This airflow is critical to maintaining fruit quality and shelf-life. The configuration that is now used for almost all A15C telescopic cartons is reasonably new. Cartons with this configuration are called super-vent cartons, and this configuration is highly recommended.

Cartons are manufactured from corrugated board according to strict specifications. The corrugated board is either in three layers, being liner-fluting-liner, or five layers, being

liner-fluting-liner-fluting-liner. Board with five layers is stronger, and is used for the inners of telescopic cartons, and for open-top display cartons.

Cartons used for export citrus cannot be manufactured from recycled paper. When paper is recycled, the fibres that make up the paper get shorter every time it is recycled, weakening the paper. Virgin paper still has long fibres, making the paper stable and strong. Cartons are exposed to cold, heat, moisture, and pressure on its way to the overseas market, and they have to be as strong as possible to withstand this exposure. It is also important that the paper used for the fluting and liner is of the right thickness, or weight, expressed in grams per square metre. If the paper is too thin, the cardboard will also not be strong enough.

Cartons are printed with special designs, usually reflecting the branding under which the fruit is being exported, but sometimes just in plain colours. The ink that is used is water-based and environmentally-friendly, so that all cartons are recyclable and biodegradable. At the same time, the cartons are cut into a particular configuration and the ventilation holes are punched through. The cartons are also scored to make them easy to fold.

Cartons are delivered to packhouses in flat packs. They are erected by special machines. One type of machine is used for making telescopic cartons, and another for open-top cartons. The most modern machines can be set to make different types of open-top cartons, some of which have double-sided ends, and others with fold-overs.

Bulk Bins

Bulk bins are large cartons which are used for exporting processing fruit. They are usually not printed, and are also delivered to the packhouse in flat packs. They are erected at the packhouse using strapping, and special corner pieces to strengthen them for stacking. Bulk bins are stacked two high on pallets.

Fruit Labels (PLUs)

Fruit labels, also called PLUs, which stands for price look-up codes, are attached to fruit and reflect the brand of the fruit. Sometimes they also display the PLU code for the fruit, hence this common name for them. The PLU code is a four- or five-digit code that is used for fresh produce, to identify the product by commodity, variety and size group.

Fruit Wrappers

Fruit wrappers are used to wrap some of the fruit in a carton, according to the requirements of the market. Fruit wrappers are made from thin tissue paper, and can be plain or printed with product branding. The paper usually has a thin waxy layer and feels slightly slippery to the touch. This makes the paper easier to handle while wrapping and helps to protect the fruit when it is packed. The wrappers are already cut to size and one wrapper per fruit is used. It is common practice now to only wrap some rows, often diagonally, in the top layer of fruit in the carton, because wrapping is detrimental to the cooling process during shipping.

Pallets

Pallets are critical to the security and safety of export products. Pallets take a lot of abuse – every time the fruit has to be moved, the pallet is lifted with a forklift or some other piece of machinery, which means they can easily be damaged. If the pallet is not

properly constructed using, for example, inferior wood or nails that are not large enough, it can easily break, compromising all the cartons on the pallet.

The wood used for pallets has to be treated to protect it against pests and fungal growth. If this is not properly done, the pallet will be weakened by infestations of this nature. The pallet itself can even become a source of contamination.

Pallets must also be constructed according to the correct design. For citrus exports, what is known as the 1210x1010mm pallet for export citrus, or more informally as the CRI pallet, has been designed and tested to be the strongest and most stable configuration of slats for transporting citrus cartons. Pallets that are not made according to the CRI design often have the slats in the wrong places, or are too thin, resulting in the bottom cartons falling off the slat edge, compromising the integrity of the whole stack.

All pallets must be constructed according to specifications, and it must carry the ISPM15 mark, which means that it complies with the requirements of the Guidelines for Regulating Wood Packaging Material in International Trade, which was issued by the International Plant Protection Convention (IPPC) Secretariat.

Securing Sheets

Securing sheets are used when palletising open-top display cartons. Securing sheets are placed between some layers of cartons, to keep the stacks of cartons from separating and falling off the pallet. Securing sheets also have ventilation holes in them. They are available in different configurations, to go with different open-top cartons. It is important that the right securing sheet is matched with the right carton, otherwise the ventilation holes will not line up and the airflow through the palletised fruit will be obstructed.

Pallet Caps

Pallet caps are used with open-top cartons to cover the top layer on the pallet, and to cover the top bulk bins used for processing fruit. It is made from cardboard, and folded before being put in place.

Corner Pieces

Corner pieces and strapping are used to secure the cartons on pallets, so that the cartons remain stable and do not topple off the pallet. Corner pieces are made from laminated cardboard and must comply to manufacturing specifications.

Packing Material Specifications

The cost of packing material constitutes the largest component of the total packing cost for a carton of export citrus, with the carton itself being the priciest component. Packing material also has to keep the fruit safe and healthy on its way to its destination.

On this journey, it will probably be transported by truck, handled and stored in a cold store or a fruit terminal – or both, loaded directly into the hold of a ship, or into a container and then onto a ship, transported across the sea, unloaded in the receiving port, and transported to its destination. The packing material will be exposed to cycles of cold, heat, moisture, humidity, friction, pressure, and repeated handling during this journey. It is critical that the

packing material must protect the fruit throughout this journey, and play its part in ensuring that the fruit arrives at the destination in the best possible condition.

Take the time to weigh up the cost of quality packing material against the cost of failure of inferior packing material – the cost of losing even one pallet of fruit can nullify the supposed savings on inferior, cheaper packing material. It is simply not worth taking the risk.

The CRI Postharvest Technical Forum issues the Packaging Material Specifications and Palletisation Protocols at the beginning of every year. The protocol sets out in great detail the specifications for all types of cartons used for citrus export, standards and specifications for pallet construction, palletisation protocols, and other information to assist the grower and the packhouse to verify that their packaging material manufacturers and suppliers are accredited and up to standard.

Additionally, the Postharvest Technical Forum also facilitates a self-regulatory accreditation system that has been established by carton manufacturers. This system involves printing a quality mark on cartons that comply with the specifications of the Forum. All cartons used for packing export citrus must have this mark.

Packing Instructions

Before we look at how to pack citrus into different types of cartons, we need to ask ourselves: How does a packer know what fruit to pack, which carton to use, whether to wrap the fruit, whether the fruit should be labelled, and what label to put on the carton? And, taking into account that every packer at every table is likely to be packing something different: How do the supervisors coordinate and manage it so that packers get what they need, and the fruit ends up in the right boxes, in the right place?

This information is all contained in packing instructions. A packing instruction is given to supervisors of different divisions in the packhouse for every run. It contains all the information needed to ensure that the fruit packed during the run will comply with the different market requirements. The supervisor in control of the automated grading system uses the packing instructions to set the tolerances on the grading system in line with the market requirements. The supervisor at the packing tables needs to communicate this information to the packers so that they are clear on their instructions. The quality control supervisor uses the packing instructions as the standard for inspections. The carton erection supervisor uses the packing instructions to make the right cartons and ensure that enough are available for the run.

Packing instructions differ from packhouse to packhouse, and will often contain codes and abbreviations unique to that packhouse. But the purpose remains the same for all packhouses, and we can safely say that packing instructions would contain the following information:

- Citrus type and cultivar
- Fruit grade and size
- Target market
- Country of destination
- Carton type
- Brand
- Fruit labelling
- Fruit wrapping

- Cartons per pallet

The packing instructions may also include the order number and the number of pallets ordered, so that the supervisors can plan ahead for the packing run.

These instructions can be communicated to packers in different ways. Some packhouses have visual boards with instructions to packers, while others use television screens that can be easily updated.

Fruit Labelling

If the market requires this, fruit can be labelled in the packhouse with branded labels that sometimes display the PLU code for that fruit. Fruit labels are usually put on the fruit by automatic labellers that are close to the automated grading system. Labelling banks are installed over the lines coming out of the grading system, and automatically put a label on a fruit if the automated grading system instructs it to do so. More than one labelling bank can be installed, for when fruit of different brands is packed.

Sometimes the buyer wants only the top layer of fruit to be labelled, and for the label to be placed in a particular spot on the fruit. In such cases the fruit has to be labelled by hand by the packer after they are done packing the carton. There are smaller labelling banks that can be installed with automated place packing machines to label fruit in this manner.

Packing Practices

Preparation

With each packer now aware of their packing instructions, and with fruit of the right quality and size heading their way from the automated grading system, the packer needs to gather all the materials and equipment they need. This includes fruit wrappers and labels, as required.

A few different systems are used to deliver cartons to packers in packhouses. The most common is the monorail. A monorail runs above head height but within reach of people at the packing tables, and it has hooks from which cartons are hanged. In the carton erection area, the rail is constantly replenished with all the carton types that are being used at any given time. The rail runs past all the packing tables, and packers remove the cartons they need, as and when they need them. Systems that are becoming more prevalent deliver the right cartons directly to packing tables, using either conveyor belts running under the tables, or chutes if the carton erection area is above the packing floor.

Packing Diagrams

There are two methods for packing fruit in cartons. By far the most prevalent is place packing, which is when fruit is placed according to packing diagrams into specific patterns, dependant on the carton type and the size of the fruit. A specific number of fruit is packed into the carton when this method is used. The second method is jumble packing, when fruit is simply jumbled into a carton until it reaches a certain weight.

It is important that all the packers know and adhere to the packing diagrams, to ensure that every carton of a specified type and size will be identical. Packing diagrams have been developed to find the most efficient way to fit the number of fruit in a specific size category into a carton. Let's look at two examples.

This is the packing pattern for count 72 oranges packed in an A15C telescopic carton. This information is in the header of the diagram. Below is the pattern that the fruit should be in. The number in the fruit at the top of each row is the number of fruit that should be in that row. The meaning of "4 layers (18)" is that four layers should be packed in the carton in this pattern, with eighteen fruit in each layer. Four multiplied by 18 gives us 72, the number of fruit that must be packed into the carton.

This is another example, of lemons of count 189 in an A15C carton. This is different, because the layers are not the same. The first layer will have seven rows, of five, four, five, four, five, four and five fruit, bringing the total fruit in the layer to 32. The second layer will again have seven rows, but this time with four, five, four, five, four, five, and four in the rows, bringing the total number of fruit in that layer to 31. The fruit in the second layer nestles into the gaps between the fruit in the first layer. We can see this alternating pattern from the text below the diagram, where we learn that we need to pack six layers like this, bringing the total to 189, the number of fruit that should be in the carton.

Place Packing

Before we start, it is important to remind packers that they are the last people to see and handle the fruit before it is received in the overseas market. If they find any fruit in their trays that is not up to standard, especially if the fruit is damaged or injured, they must not pack this fruit. If they find many poor quality fruit , they must alert their supervisor immediately.

To start, the packer places the carton next to them on a flat surface where they can easily reach it and where it is secure and won't move around. The first layer of fruit is packed as per the relevant packing diagram, starting in one corner of the carton. The fruit should fit comfortably if the right packing diagram is being used. Once the first layer is complete, the second layer is added, and so on, until the required number of fruit has been packed in the number of layers prescribed by the packing diagram. In most cases, the fruit in upper layers will nestle between those in the layer below. Don't squeeze fruit too tightly into the carton, especially if you are packing more sensitive fruit types, such as soft citrus, because this will damage and bruise the fruit.

If the top layer of fruit must be labelled, the packer will now apply those labels as per instructions. This is usually done by hand.

Sometimes buyers also want some or all of the fruit to be individually wrapped. The packer would have been instructed whether all of the fruit needs to be wrapped, or only some of them, such as alternative layers or diagonal rows. Wrapping is mostly cosmetic, so it is often the top layer of fruit that is wrapped. The packer picks up a wrapper with the dominant hand, on which they will often have a rubber thimble, or fingerette, that makes it easier to pick it up. The fruit is picked up with the left hand, and put inside the wrapper. The wrapper should be wrapped right around the fruit and twisted slightly at the bottom so that it remains in place.

Once the carton has been packed and the lid has been put in place, if there is one, the carton labels are stuck onto the side of the carton. Packers must ensure to label the correct end of the carton, in the correct position, straight and neat, and to smooth down the label so that the corners don't lift. Labels must never overlap so that information is concealed, and they must never be peeled off and replaced once they are stuck on.

Jumble Packing

For jumble packing, the packer puts the carton on a scale and scoops the fruit into the carton until the desired weight is reached. When the carton has been filled, the carton is labelled in the same way as for place packing.

Weighing Cartons

The packed cartons are now placed on a track or rail system that moves cartons from the packing table to palletisation. In more advanced facilities, scanners scan the barcodes on the cartons and direct them to the right palletisation station. In others, all the cartons move along one track and it is up to the palletiser to select the cartons that belong on their pallet, as directed by the carton label.

On the way to the palletising station, some or all the cartons are weighed to ensure that the packed cartons achieve the minimum weight required by the market. Fruit lose weight in transit due mainly to moisture loss. Packhouses therefore aim to pack cartons about eight to ten percent overweight. For example, an A15C carton will usually weigh around 16kg right after being packed.

Automated Packing Machines

Many packhouses are introducing automated packing machines. There are two types of automated machines, one which does place packing, and the other jumble packing.

Automated Place Packing

Automated place packing machines use plates on which fruit is arranged in indentations on the plate, placed and spaced according to the relevant packing diagram. The plate is moved along a conveyor and, after being labelled as required, stops under a set of suckers that correspond with the indentations in the plate. The fruit is lifted off the plate by the suckers, the plate is returned to the starting position, and the fruit is placed into a carton below the plate. If alternate layers are required, the suckers turn the fruit around before placing them in the carton. There are particular sets of plates and suckers for each carton type, fruit size, and packing diagram.

Automated place packing is about two to three times faster than manual packing. If this technology is available to the packhouse manager, the category of fruit with the highest volume will be directed to the automated lines.

Automated Jumble Packing

In automated jumble packing machines, the fruit is collected in a hopper that has an integrated scale. As soon as the fruit in the hopper is the right weight, the fruit is dropped into the carton below. The fruit is gently shaken around to settle it down, and the carton is moved on to palletisation. Automated jumble packing machines can also be used to fill other containers, such as bags.

Palletisation

Stacking and securing cartons on pallets is the next step in the packhouse process. This is a critical step. By far the most claims from overseas buyers result from the cartons collapsing in transit, which can be because of poor quality packing material, but is most likely to be because of improper palletisation.

High Cube vs. Standard Pallets

Traditionally, fruit was predominantly exported in specialised reefer ships. The height in the decks of these vessels only permitted a pallet height of two meters. These pallets are referred to as standard pallets.

Over the past ten years there has been strong growth in containerised shipping, after the development of the high-cube integral container. Containers allow for a pallet height of 2.4 meters, which means one or two more layers of cartons could be added to standard pallets, depending on the carton type. These pallets are called high-cube pallets. Twenty high-cube pallets can be loaded into a high-cube integral container, while remaining within the maximum permissible height to allow for sufficient air circulation within the container. Using high-cube pallets results in considerable cost savings, because so many more cartons can be stacked on each pallet.

When high-cube integral containers were originally introduced, containers were stuffed at cold stores, where standard pallets had to be broken up to make high-cube pallets before they were loaded in containers. There were some challenges with this practice, and packhouses soon started to stack high-cube pallets at the packhouse, so that they could go straight into containers when they reached the cold store. More recently, packhouses started filling containers at the packhouse already, from where they were transported to the harbour where they were plugged in to maintain the cold chain, and then loaded straight onto container ships.

Many of the initial constraints of high-cube pallet stacking have been resolved over time. Initially, not all cold stores were able to store high-cube pallets in their racking systems. Cartons were also not designed to be strong enough to carry the extra weight, but this has also now been improved. Recently the scarcity of containers and a shortage of plug-points at the harbour have been the biggest constraints on using containerised shipping. Still, around 90% of citrus is now exported from South Africa in containers, meaning that 90% of pallets are high-cube.

Pallet Stacking Patterns

Pallets used for export citrus are 1210mm long by 1010mm wide. Cartons are sized to fit onto pallets in particular configurations. For instance, telescopic cartons, including the popular A15C, measure 400 by 300mm. This means that three cartons can be placed end to end along the length of the pallet – 400 times 3 equals 1200 – and two short sides and one long side can fit along the width of the pallet – 300 times 2 plus 400 is 1000. In the same way, the most popular open-top display carton size is 600 by 400mm. Two of these cartons can be packed end to end along the length of the pallet – 600 times 2 equals 1200 – with another row of three cartons placed perpendicularly to the first two to complete the layer – 600 plus 400 equals 1000, and 400 times 3 equals 1200. All cartons are designed to fit on pallets in some configuration or another.

This is the purpose of pallet stacking patterns, which have been developed to prescribe how cartons of different sizes should be placed on pallets to fit properly. Pallet stacking

patterns can be found in CRI's Packaging Material Specifications and Palletisation Protocols.

Typically, telescopic cartons are stacked with at least the first three layers in the same pattern, which is called column stacking, and then alternating layers with the pattern of the cartons reversed. This is referred to as brick stacking.

Open-top display cartons are column-stacked all the way to the top. The cartons have special tabs that allow the stacked boxes to interlink. This gives some vertical support to the columns by ensuring that the cartons are securely lined up in the column. The stacking patterns are designed to fit the cartons onto the pallet, according to the carton size.

Palletising Stations

Packed cartons are heavy, and can weigh up to 17kg, which is the packed weight of a carton of grapefruit. The most common telescopic and open-top cartons both hold 15kg of fruit. The cartons are also stacked high, at 2m for standard pallets and 2.4m for high-cube pallets. Seventy cartons are stacked on a standard pallet of A15C cartons, and eighty on a high-cube pallet. From these simple facts, it is clear that palletising is hard work, and that a person cannot stack a pallet to the top while standing on the ground. It will be almost impossible for a person of average height to reach the top of a pallet and put the cartons neatly in place.

There are various systems in packhouses aimed at making palletising easier, while ensuring that fruit quality is maintained throughout the process. Pallet elevators are popular, where the palletiser stands on a platform or walkway, and the pallet is on an elevator next to him. When the elevator is at the top with a new pallet on it, it is at just the right height for the palletiser to put the bottom layer of cartons in place without having to bend or stretch too much. As he adds each layer, the palletiser uses the hydraulic system to lower the platform with the pallet on it, until the elevator eventually reaches the bottom, and the top layer of cartons on the pallet is level with the palletiser. This system allows for efficient palletising, and allows the palletiser to put the cartons in place without having to throw them, while also avoiding injuring himself.

However, in most packhouses pallets are still stacked from floor level. Palletisers are given steps that they place next to the pallet and climb on as the pallet is stacked higher. It is important that they use the steps. If they don't, they end up launching cartons to get them into the right spot. This can cause injury and bruising to the fruit, injure the palletiser, and will definitely disturb the neat packing patterns of the cartons.

The latest development is a move towards automated palletising systems. In these systems, the cartons move along a conveyor to a plate where the cartons are arranged into layers. When the layer is complete, it is lifted up and placed on the pallet. These systems are used together with automated packing machines.

Pallet Stacking Practices

Before starting, it is important that the palletiser has everything required to hand, including pallets and securing sheets if stacking open-top cartons. If stacking from floor level, the palletiser must also have their steps to hand.

Before stacking the pallet, the palletiser must make sure that the pallet is sturdy, and carries the ISPM15 mark. The pallet must have no wood splinters or nails sticking out

that can catch on or stick into the cartons and fruit. They must also check that there is no fungal growth on the wood.

Pallets are stacked with identical cartons of fruit, meaning that all the fruit in the cartons must be of the same class and size category, packed in the same way, and destined for the same market. The palletiser can identify the cartons by looking at the carton labels. Some packhouses have automated systems that scan barcodes on the cartons and direct them to the right palletising station. Others have systems where the palletiser scans every carton before stacking it, thereby eliminating errors.

When placing the cartons in the first layer on the pallet, it is very important to line up the ventilation holes in the cartons with openings between the pallet slats, while ensuring that the four corners of each carton rest squarely on wood. Lining up the ventilation holes allows for airflow, which is vertical on ships and in containers, to reach the fruit during cooling.

The cartons are then stacked in layers, according to the stacking pattern for the particular carton type, and in the number of layers prescribed by the stacking pattern. The side of each carton carrying the label must always face outwards. The palletiser should pay attention to the cartons, making sure that they are not damaged or softened by moisture. Cartons on pallets carry all the weight of the cartons above them, and this can be considerable for cartons in lower levels. If the cartons are not sound, they will collapse under the weight, which can lead to the entire pallet collapsing.

For open-top display cartons, securing sheets must be put in place to prevent the columns from collapsing outwards. The layers between which securing sheets must be placed is also prescribed in CRI's Packaging Material Specifications and Palletisation Protocols for each carton type.

Once the pallet has been stacked to the top, it is moved by forklift or by ride-on pallet jacks to the securing station. Ride-on pallet jacks are becoming more popular for use in packhouses because they are smaller than forklifts, more manoeuvrable, and less noisy and dangerous.

Securing Pallets

Stabilising cartons on pallets is extremely important. The fruit that is stacked on a pallet can weight more than a ton. If the pallet collapses it will likely destroy the fruit and endanger humans nearby. For this purpose, four laminated paper corner pieces are put in place, and horizontal straps are added in a few positions on the pallet. Corner pieces protect the corners of the cartons, and keep pallets neat and square. Corner pieces of different lengths are used on standard and high-cube pallets. The Packaging Material Specifications and Palletisation Protocols prescribe the specifications for the corner pieces.

Strapping is used to hold the cartons on a pallet together. Exhaustive research has gone into determining where the best positions are for strapping each carton type to ensure that the cartons on pallets remain secure. This information has been written into the Packaging Material Specifications and Palletisation Protocols, and this protocol must be strictly adhered to.

To secure a pallet, the corner pieces are put in place on the four corners, and the strapping on either layer 4 or layer 5 is done first to hold them in place. To be effective, corner pieces must rest on the pallet. The rest of the strapping is then added, as per the protocol.

Once the cartons on the pallet have been secured, the pallet is moved to a storage area to await inspection. At this stage, the final carton labelling and pallet labels are added.

Automated pallet strapping machines are becoming more popular in packhouses. In these systems, the pallet is placed on a plate in the machine. The strapping machine then puts the corner pieces in place with mechanical arms, after which a frame moves up and down the pallet, adding the strapping. These systems are more efficient and more precise than manual strapping.

Pallet caps are put in place on pallets of open-top cartons once the pallet has been inspected. The pallet cap is put in place over the top layer of cartons, secured by a strap. Pallet caps are also used for processing fruit exported in bulk bins.

Marking

At the time of making this module, almost 2 million pallets of citrus are being exported from South Africa every year, carrying more than 150 million cartons of fruit, heading for more than sixty countries around the globe. To keep track of this enormous number of pallets and cartons, robust and efficient information management is critical. Central to this is carton and pallet labelling and marking.

As per the Export Standards and Requirements, every carton must have on it a label with at least the following information:

- The type and cultivar of the fruit
- For grapefruit, the flesh colour
- The class of fruit
- The size reference and count
- The production unit code (PUC) of where the fruit was produced
- The packhouse code (PHC) of where the fruit was packed
- The packing date code
- The country of origin
- The name and address of the exporter, or owner
- The postharvest treatments that have been used with the fruit

Additional information that is usually added includes:

- The target market
- The cold store that the consignment is going to

The carton label also has a barcode on it, encoding this information. The label must be stuck on straight and neat, with no corners that are folded or not properly pressed down.

There are very strict rules around carton marking. The label must be on the right end of the carton, facing outward when stacked on a pallet, and in the exact position. Labels may not overlap, and they must never be peeled off and replaced after being stuck on. This is considered tampering and is grounds for immediately rejecting the fruit for export. Additional information, such as the details of the exporter or the cultivar, can be added on more labels.

Conclusion

We have now reached the point where, from the jumble of mixed, dusty fruit we received from the orchard, we have created ordered pallets stacked with cartons filled with clean, treated fruit which is protected from postharvest decay, with fruit of the same size and grade, and cartons secured on the pallet and neatly labelled. The fruit, cartons and pallets also comply with regulations and with market requirements. All that remains is for the fruit to be inspected and declared fit for export, and then to be loaded for transport to the harbour.

Citrus Packhouse

Module 8:
Quality Management

Learner Guide

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Citrus Growers' Association OF SOUTHERN AFRICA
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1st edition 2022

The content of this module is based on audio-visual material produced by the Citrus Academy.

Scripted by:
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Visual material production:
Sagritex (Pty) Ltd

Additional information sources:
Citrus Research International

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Produced by

In collaboration with

With the support of

Contents

Introduction

We have now looked at the complete packhouse process, from where fruit is received to the point where it has been packed in cartons and stacked on pallets. The last step, before the pallets can be loaded for transport, is inspection and approval for export by the PPECB.

But end-point inspections are only part of the quality management system in a packhouse. The essential components of the system also include accreditation, fruit intake assessments, and internal quality assurance systems. The final product inspections not only verify the suitability of the product for export, but also provide information about how well the quality management systems are performing. If the packhouse product consistently meets the quality requirements, the product quality management systems are functioning well.

The purpose of quality management in the packhouse is twofold. Firstly, it aims to ensure that fruit leaving the packhouse is safe for human consumption and will not expose any person handling or consuming it to undue food safety risks. Secondly, it aims to ensure that the final product leaving the packhouse complies with the regulated Standards and Requirements for export fruit, and with the Standards and Requirements of the target market and overseas client. In the module on sorting and grading we look at export standards and requirements. Please review this module to ensure you understand these concepts.

Packhouse Accreditation

Packhouses must maintain high food safety standards to ensure that their products will not cause harm to any person eating or handling them. SA GAP certification is the minimum food safety requirement for any packhouse to operate, including those that only pack for the local market. Export target markets and clients require packhouses to be certified by additional accreditation schemes.

The most common of these are GLOBALG.A.P., which applies to on-farm packhouses, BRC with HACCP as a requirement, and SIZA. It is also quite common to have additional food safety checks, as required by the specific buyers whom the packhouse supplies. Audits for accreditation schemes are done by external, independent certification bodies. More information about all these schemes is readily available.

GLOBALG.A.P. is a global organisation aimed at ensuring safe, sustainable agriculture by creating a set of standards for good agricultural practices. One of these models is the Produce Handling Assurance (or PHA) standard, which applies specifically to cooling, packing, re-packing, handling, and storage facilities. GLOBALG.A.P. also offers add-on certifications, such as GRASP, which is the GLOBALG.A.P. Risk Assessment on Social Practice. These add-ons are sometimes required by clients such as supermarket groups.

BRC certification is now required by most leading food retailers. The standard was developed by the British Retail Consortium, or BRC, and aims to assess the ability of food processing facilities, including packhouses, to comply with food safety standards and demonstrate due diligence. BRC audits focus on the processes and systems in the packhouses. The principal requirements of the BRC standard are the adaptation of HACCP, having a documented quality management system, and demonstrating control of factory environmental standards, products, processes and personnel.

HACCP stands for Hazard Analysis Critical Control Point. The primary goal of HACCP is to prevent problems from occurring by proactively identifying and pre-empting possible hazards. The seven principles of HACCP are hazard analysis, identifying critical control

points, establishing critical limits, monitoring procedures, taking corrective actions, verification procedures, and recordkeeping and documentation.

SIZA stands for the Sustainability Initiative of South Africa. SIZA is a non-profit company which was established by the fruit industry. It provides a Standard and system to measure and communicate the performance of the businesses on ethical and environmentally sustainable practices. Third party auditors verify this performance as part of the overall approach to provide stakeholders with the required assurance.

Accreditation systems may seem to be just another compliance requirement, but it can and should be used as an opportunity to improve the operational standards of the packhouse by benchmarking it against others, with audits as an objective assessment of current practices.

Occupational health and safety is an important component of accreditation systems, in addition to being a regulatory requirement as all packhouses have to comply with the Occupational Health and Safety Act. Packhouses are highly industrialised environments, with equipment, machinery, vehicles, and agrochemicals that can cause injury to workers and visitors. Measures aimed at limiting the probability of injury must be in place and enforced, and notices must be put up to create awareness about possible hazards.

Fruit Intake Assessment

A fruit intake assessment is done at receiving. When the packhouse starts tipping the first fruit from an orchard, a sample of the fruit is analysed to determine the average quality and size range. This information is used to make decisions about the packhouse process, such as how many sorting stations to use. If the fruit is of good quality with a high pack-out percentage, less sorting on the line is required.

In addition to this assessment of external quality, the quality control officer conducts tests to determine the internal quality of the fruit in the intake sample. In the module on sorting and grading during the discussion on internal quality factors, we describe in detail how these tests are conducted. This information is recorded and used to verify that the fruit meets minimum export Standards for internal quality.

The quality control officer also conducts a cull factor analysis, which can be done with the intake sample, but can also be done with a sample taken after the washing system, when it might be easier to identify marks on the fruit. For the cull factor analysis, the fruit deemed unfit for export is sorted according to the reason for being unfit. These reasons may include under- and oversize, colour, pest or disease damage, decay, and fruit injury, with special attention to picking injuries. Fruit with pest and disease damage is further separated per the type of damage. This information is recorded, and feedback is given to the production unit.

Internal Quality Assurance System

Every packhouse needs to implement a quality assurance system with components that ultimately guarantee overall product quality. In this sense, the packed and palletised fruit is the product, while quality refers to the quality of the fruit itself – whether it is safe, protected from postharvest diseases, and complies with market standards and requirements –, the quality and soundness of the packing material, and the quality of packing, palletisation and marking practices.

The perfect product looks as follows: The right number and quality fruit, packed using packing material that complies with packing material specifications, with the right number of cartons stacked neatly and squarely in the correct stacking pattern, on a sound pallet that complies with specifications, with strong corner pieces precisely on the corners and resting

on the pallet, strapped together with the right number of straps in the prescribed positions, with a pallet cap and securing sheets in place if required, and with labels on every carton stuck down squarely and neatly without any peeling corners. This is what a quality assurance system must aim to achieve with every single pallet that leaves the packhouse.

The principle of quality-at-source is fundamental to quality assurance. This is where every person who handles any part of the final product or controls any part of the process that impacts on product quality, takes responsibility for maintaining quality in that moment, prior to external control or supervision. This requires that every person in the packhouse must fully understand the impact that their actions can have on the final product.

Quality Supervision

Supervisors and section managers are principally responsible for quality assurance in their particular section of the packhouse process. It is up to them to monitor and correct the behaviour and actions of the workers in their sections, and to ensure that the quality assurance system is maintained. They are also responsible for doing spot-checks, such as on packing material, fruit quality, and stacked pallets.

Every packhouse also has quality control officers who are responsible for monitoring quality control points to ensure that processes are running within set parameters, thereby ensuring that product quality is being maintained throughout.

Quality Control Points

The number of quality control points differs from packhouse to packhouse, but as many of these points should be put in place as is necessary to assist with operations, and to give comfort that process and product quality is being monitored well enough to ensure consistently high performance of the packhouse.

One way of verifying that processes are running within set parameters is by taking fruit samples at various quality control points along the packline and checking that sorting and grading practices are accurate. This may include samples taken right after the main sorting stations from the main line and from the processing lines, as well as samples taken by the automated grading machine from any of the categories it is grading at the time. These samples are analysed by the quality control officer to determine whether the correct standards are being applied by the sorters and grading system. An approach that uses regular and random sampling patterns is encouraged to ensure the performance is being monitored thoroughly.

Other quality control points that are monitored closely are the settings for the de-greening chambers, and parameters such as pH, temperature, and the concentration of actives in the drench, washing system and fungicide treatment solutions. In some packhouses this is done by the quality control officers, but in some cases the packline manager has this responsibility.

An important quality control point is at the packing tables. Quality control officers regularly inspect packed cartons of fruit to assess whether they meet market standards and requirements, and whether the fruit inside the cartons corresponds with the label on the carton.

The final quality control point is after palletisation, when all stacked pallets should be checked to verify that they comply with the quality standards that the packhouse sets for its final product. Remember, never let a pallet leave the packhouse that you are not proud to claim as your own, and happy to call proudly South African.

Retention Samples

Best practice is for the packhouse to keep one carton from every consignment of fruit that is dispatched, until the consignment reaches its destination, and is accepted. This is called a retention sample. Retention samples are the last important component of quality assurance. They allow the packhouse to monitor fruit quality even after a consignment leaves the packhouse door. If the packhouse management detects quality issues with the retention samples, they can choose to divert the consignment in question to a different market.

Retention samples are kept in special rooms, which can be cooled or at ambient temperature, depending on the quality parameters for which the packhouse wants to monitor. The main purpose of retention samples is to verify reports and claims from the fruit importer. For instance, if there is a claim that the fruit in a consignment exceeds maximum residue levels, the fruit in the retention sample can be tested to verify whether this is the case. Likewise, if there is a claim that the fruit in the consignment does not meet the export standard, the retention sample can be assessed to verify the claim.

PPECB Inspections

The Perishable Products Export Control Board, or PPECB, is a public entity that is the mandated certification agency for perishable products intended for export. The PPECB delivers inspections and food safety services assigned to it by the Department of Agriculture, Land Reform and Rural Development, or DALRRD. The European Commission also recognises the South African inspections by the PPECB as equivalent to that of the European Union inspection bodies, which means that less frequent checks are performed at the port of import into the EU.

The PPECB provides two types of inspection services used by the citrus industry, namely quality inspection services at packhouses, and cold chain services.

The first purpose of packhouse quality inspections is to ensure compliance with Export Standards, and the quality and shelf-life of the fruit. The second purpose is to verify compliance with phytosanitary requirements. Note that the PPECB will only inspect against the regulated Export Standard, and not against any specific Standards set by a client or export agent.

At the start of season, the PPECB conducts a facility inspection, during which they verify that the packhouse and production unit is registered with DALRRD, that valid food safety certificates are in place, that registrations for special markets have been done where required, and that the packhouse facility is suitable for packing export citrus and has the required equipment for inspection. These facility requirements include sufficient space, reliable electricity supply and potable running water supply, sufficient light on the packhouse floor, sufficient inspection space and equipment, lockable cupboards, safe storage space for flammable material such as packing materials, and so on. Throughout the season, the packhouse must ensure that the PPECB inspection area and equipment are compliant with the requirements. A checklist, which also includes specific requirements for specific kinds of fruit, is used during this inspection.

Throughout the season every pallet of fruit that is packed in the packhouse must be inspected and passed for export by PPECB inspectors before it can be transported to the port. When the packhouse has a consignment ready for inspection, it sends a request to the local PPECB office. To ensure a quick response and avoid delays, the PPECB stations

inspectors in all citrus-growing areas throughout the season, and even places inspectors permanently at large packhouses.

In preparation for inspection, the inspector is given the consignment note for the fruit to be inspected so that the correct standards can be applied. The consignment note can be in hardcopy or an equivalent electronic file containing the same information. It is essential that the document or file contains all the relevant, correct information, and is readily available to the inspector. If the fruit is destined for a special export market, this will also be indicated. Pallets destined for special and normal markets should be in separate consignments.

Special markets refer to export markets that have specific quality, marking and inspection requirements. These special requirements are based on bilateral agreements with these countries, and form part of the regulated Export Standards. The requirements for special markets change from time to time, and it is important that packhouse management and the quality assurance team are familiar with any special requirements for their target markets. Special market requirements can be found on the DALLRD website.

For phytosanitary markets, fruit inspections also include checking for the presence of specific pest insects and disease symptoms, as per the requirements of the specific market.

For most markets, a standard inspection procedure is employed. A sample of 2% of the cartons on a pallet or consignment is taken. The boxes are marked carefully to ensure that they can be returned to the correct place, so that traceability is maintained. The carton is opened, and the fruit is examined by the inspector. The number of fruit that is examined from each carton depends on the target market. The evidence and outcome of the fruit inspection are captured electronically, or manually on finding sheets.

If a PPECB inspector is certified as competent for a kind of fruit, such as citrus, it means that they have been trained on the Export Standard for that kind of fruit for each export market. They undergo intensive theoretical and practical training, after which they work under the supervision of a senior inspector until they are competent to work alone. Inspectors always carry the Standards and Requirements with them as a reference while doing inspections.

The inspector also verifies that all the cartons on the pallet comply with marking requirements, especially for special markets. For this reason, it is important to make sure that the inspector has access to all sides of every pallet. Note that labels must never be stuck over one another, as superimposing of labels is not allowed in many markets and can lead to rejection of the consignment.

If the inspectors find that the fruit in the consignment complies with the relevant Standard that is applied, the consignment note is stamped, and each pallet is marked as approved for export. If pallets are loaded into a container at the packhouse, the PPECB inspector monitors the loading process, provided that they are a competent cold chain inspector as well. The inspector seals the container.

Maximum residue level, or MRL, samples are taken once at the start of packing for each production unit for each fruit type, after which samples are taken every three weeks. The PPECB inspector takes the samples for MRL testing during the inspection of the first consignment. The MRL analysis is conducted by a certified laboratory officially recognised by DALRRD. The sample is tested for all actives on the MRL list applicable to the specific target market. The results are received within four days, but the consignment from which the sample was taken can be despatched to the port in the meantime. The grower is informed of the outcome of the tests. In case of non-conformance, a follow-up sample is taken and analysed, and the frequency of sampling for that fruit type is increased.

The outcome of a quality inspection is valid for 28 days for oranges and grapefruit and for 21 days for soft citrus after the inspection is conducted. If the fruit is delayed in the port or cold store for longer than this, it must be re-inspected to verify that the fruit quality still complies

with the export standards. For this purpose, the PPECB stations inspectors at the fresh fruit terminal at the port, where they also conduct inspections from time to time along with DALRRD inspectors.

PPECB inspectors have the best interests of the South African fresh produce industry at heart. Their purpose is not to play policeman, but rather to provide a service to growers and packhouses and to support them in achieving the best possible returns from exporting fruit. They are always willing to help, to answer questions, and to assist with ensuring that standards are met.

Conclusion

Quality is a result of a process. To achieve the required quality, whether in fruit selection, how fruit is packed, quality of packing material, quality of palletising, or quality of logistics and handling, there is a process made up of many steps and stages, each one dependent on a person or a team following a proper process, complying to a standard operating procedure, and making good decisions. The better the process and the better the team, the more assured you are of a quality outcome. It is vital that you think in terms of a quality management and assurance system, and not just control.

Think honestly about the following important questions:

- Are your quality assurance process and outcomes well-defined and communicated?
- Does every person in the packhouse understand their contribution to quality?
- Do you accurately measure and track quality performance?
- Do you experience recurring quality problems? If so, look at your process and your practices, identify root causes and implement a permanent solution.
- Are you relying too much on final inspections, or inspections by an external party to manage quality? If so, have a good look at how well your quality control and assurance system is embedded in your teams.
- Are you assuring a quality product to the client by working closely with your upstream suppliers, including growers, equipment and machinery suppliers and materials suppliers, and downstream service providers, such as logistics, port services and cold stores?
- How close are you to zero defects?

Citrus Packhouse

Module 9: Logistics

Learner Guide

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1st edition 2022

The content of this module is based on audio-visual material produced by the Citrus Academy.

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Produced by

In collaboration with

With the support of

Contents

Introduction

The success of the citrus industry in southern Africa depends on reliable and efficient logistics. About 75% of the citrus produced in South Africa is exported as fresh fruit, generating 95% of the industry's income.

About half of the citrus exported from South Africa goes through the Durban port, with the rest distributed between Cape Town in the Western Cape, and Gqeberha and Ngqura in the Eastern Cape. From these ports, citrus fruit is shipped to more than thirty-five ports of destination across the globe. The ports of destination, to where the most citrus is shipped from southern Africa, are Rotterdam in the Netherlands, London Gateway in England, St Petersburg in Russia, Jebel Ali in the United Arab Emirates, and Shanghai in China.

The Citrus Growers' Association of Southern Africa

The Citrus Growers' Association of Southern Africa is funded by the citrus growers of South Africa, Zimbabwe and Eswatini. It plays a very important role in securing and retaining access to foreign markets for fruit from southern Africa. It represents citrus growers in trade negotiations with importing countries and undertakes research to support these negotiations.

The CGA also assist on a high level with logistics development, engaging stakeholders all along the logistics chain. The strategy around logistics development is adapted to the current situation and concerns of growers. It involves enabling greater use of rail transport, increasing port efficiency, investigating and enabling the use of alternative loading ports, monitoring the availability of cold storage infrastructure, and supporting the development of logistics IT and information systems.

Shipping Methods

Before we look at the chain of events that moves citrus fruit from Letsitele to London, or from the Sunday's River to Singapore, we need to understand the two methods used for shipping citrus to overseas markets.

The first method, which has been used for the longest time and is therefore known as conventional shipping, makes use of specialised reefer, or refrigeration, ships. Reefer ships have open decks into which loose pallets are loaded. Once they are closed, the deck chambers are cooled. The temperature and relative humidity in the chambers are monitored throughout the journey. This method is sometimes incorrectly called break-bulk shipping.

The second method is containerised shipping, which is the most popular mode of shipping for a wide variety of consumer goods. Since the beginning of the century, there has been a steady rise in shipping fresh fruit in containers. Containers have the benefit of being refrigerated individually, which means fruit inside them cools down faster, and the cold chain is maintained. They are also easier to handle at the port than loose goods, which results in lower port handling fees. In 2021, about 90% of the citrus fruit from southern Africa was exported in containers.

The Logistics Chain

The term "citrus value chain", also sometimes referred to as the "supply chain", means the entire chain of events from farm to the consumer's plate, including the primary production, packing and shipping of the fruit. In this module, we use the term "logistics chain" to refer to

the section of the value chain that takes the fruit from the packhouse door to the consumer's plate.

To move neatly packed, stacked and secured citrus fruit from the packhouse to the overseas consumer requires a long chain of events with many role players and moving parts. The logistics chain for one consignment of fruit can look very different from that for another consignment. It depends on where the fruit comes from, whether it will be shipped in reefer ships or containers, and to which market and what customer the fruit is heading. It is important to understand all the logistics chains for the fruit that is exported from your packhouse, and to be familiar with the events and role players involved in each link in the chains. The specifics of the logistics chain play an important role in how fruit is handled, packed, and palletised in the packhouse.

By way of illustration, this is a fairly typical – if highly simplified – logistics chain for fruit coming from an inland packhouse in South Africa: from the packhouse, fruit is transported by truck to a cold store, where fruit is consolidated into consignments for customers, loaded into refrigerated containers and then turned in to the port, where it is loaded on a ship. The ship then sails to the port of destination, where the pallets are unloaded and transported to where the fruit is sold to the consumer.

There are many possible variations on this simplified illustration. For instance, pallets of fruit can be transported on tautliner trucks, or the pallets can already be loaded into containers at the packhouse. The cold store can be inland or close to the harbour. Pallets can be taken directly to the fresh produce terminal to be cooled in holding rooms. They can also be off-loaded at a cold store, where they are cooled before being loaded into containers. Fruit can be transported from the cold store by rail or truck. Pallets can be loaded on reefer ships, or they can be shipped in containers on container vessels. Once the fruit lands in the port of destination, there are many paths it can follow to the consumer's plate.

The Cold Chain

The cold chain refers to the section of the logistics chain from the point where fruit is cooled and remains under cooling until it reaches the customer. More precisely, the cold chain can be defined as the handling of citrus fruit through various stages of storage and transport under uninterrupted conditions at the optimum temperature and relative humidity.

Citrus fruit is cooled to slow its metabolism, to maintain its quality and shelf-life, to delay the onset of postharvest diseases, and as part of control measures for certain pests and diseases for some markets. Fruit should be cooled as soon as possible after being harvested, but once it is cooled, the cold chain must not be interrupted. This is critical, because if the fruit warms up again after being cooled, the rate of respiration increases, and the fruit deteriorates faster. It is better for fruit to rather enter the cold chain a little later, than for the cold chain to be interrupted.

However, certain types of citrus fruit are also vulnerable to cold damage when exposed to low temperatures for too long. Therefore, it is important to know the cooling regimes for the fruit packed at your packhouse. The cooling regime describes the optimum temperature and relative humidity conditions for each fruit type. The regimes result from intensive research and from bilateral agreements with importing countries, and they change from time to time.

Road Transport

The citrus industry is dependent on road transport for moving fruit from packhouses in citrus production regions to the ports. In some cases, fruit is also transported by road from

orchards to the packhouse after harvest. Road transport is a critical link in the logistics chain, and when there are disruptions during the citrus season, it causes major difficulty and even financial loss for the industry.

Disruptions are mostly due to factors outside the industry's control, such as infrastructure break-down, unrest or strikes in the transport sector, and there is not much individual growers or packhouses can do about such circumstances. The CGA, on behalf of citrus growers, engages various stakeholders when such circumstances occur, and assists with resolving the issues and normalising the situation as soon as possible.

Factors under the control of the grower and packhouse that can make a significant impact on the efficiency of road transport, include selecting a reputable transport provider with the necessary track record and capacity to provide an uninterrupted, quality service, ensuring that everyone involved is aware of the protocols for transporting the fruit safely, and ensuring that trucks are loaded properly at the packhouse.

Pallets of fruit bound for reefer vessel shipping are usually transported under ambient conditions on tautliner trucks. The consignment of pallets is consolidated in the dispatch area ready for loading. Before they are loaded, every second pallet can be wrapped in plastic sheeting. This helps to prevent chafing between cartons.

Trucks often travel long distances to the harbour, over roads that may not be in the best condition, and possibly through difficult weather conditions. The driver may have to brake sharply or take some other action that can cause the pallets to shift and even fall over. To prevent damage to the cartons and fruit, the load must be spread evenly over the truck axles, the pallets must be secured properly, and dunnage bags should be used if it is not a full load. After loading is complete, the truck sides are covered with canvas curtains to protect the pallets. The curtains must be tied down properly.

It is important that the packhouse logistics manager oversees truck loading. The logistics manager is responsible for the state in which the consignment arrives at its destination, and truck loading should never be left to the forklift operator and truck driver alone. Only once the logistics manager is satisfied with the loading, should the truck be allowed to leave the packhouse.

For pallets shipped in containers there are several options. Pallets can be loaded in containers at the packhouse, where they can either be pre-cooled before being loaded or loaded at ambient temperature and cooled inside the container while being transported. Alternatively, they can be transported to a cold store where they will be pre-cooled before being loaded.

A PPECB inspector is present while each container is loaded, to ensure the cold chain is maintained and the container integrity is compliant with best practice, and seals the container. If it was loaded at the packhouse or cold store, the container is transported by truck to the export terminal. While the container is being transported, it is plugged in and the fruit is cooled. As soon as the container is off-loaded at the port, it is plugged in again to maintain the cold chain.

Cold Stores

Traditionally, in the time before the growth in containerised shipping, all cold stores were in close proximity to the port. But now that containers are used for the bulk of citrus exports, it is more practical and sensible to locate cold stores closer to production areas or in areas outside the congestion around ports. Cold stores are privately-owned facilities which provide a service to the industry, by way of pre-cooling, cold storage, and container loading.

Typically, consignments of fruit are transported to cold stores in tautliner trucks. The fruit is pre-cooled, then stored under cooling at the cold store, until being dispatched to overseas markets. After being loaded, the containers are transported to the port, also by road. Many cold stores have plans in place to develop rail transport for taking containers to the port, which will do much to alleviate pressure on the road system.

Port Services

All seven ports in South Africa are key national assets, owned by Transnet. The Transnet National Port Authority (TNPA) provides the main port infrastructure, including vessel tracking, harbour pilot, tug boat, pollution control, fire and rescue, and berthing services. Transnet Port Terminals (TPT) operates the container and multi-purpose vessel terminals in each port.

Container ships can berth at the container terminal or at the multi-purpose terminal, while specialised reefer vessels berth at general cargo quays which are leased by private companies from TNPA. In Durban, FPT and MFT lease quays where they have fruit port terminals and where specialised reefer vessels are loaded. Both companies have quayside cold stores to receive and consolidate cargo, and load containers, and from where they also load specialised reefer vessels. FPT also leases terminals in Cape Town and Gqeberha, where they can load specialised reefer vessels.

Loaded containers are turned in to the port terminal where container ships berth. This is called the export stacks. The stack for a vessel opens three days before the vessel arrives, to allow cargo to accumulate before its arrival. The containers are plugged in while they are in the stacks to maintain the cold chain, and monitored four times a day to ensure they are functioning.

The export terminal is a customs-controlled area. Containers may not be removed from the port without a SARS customs release. The terminal operator charges a terminal handling charge, or THC, for moving the containers off the trucks, into the stacks, and onto the vessel.

Shipping

These are the major shipping routes from South Africa. There are slight variations and refinements on this simplified illustration. For instance, ships leaving Durban and sailing up the east coast of Africa will often stop at other ports along the coast as well, enabling exports to the rest of Africa. But the illustration shows clearly how South African citrus fruit is distributed around the world.

There are several shipping lines that serve South Africa. The choice of shipping line is often limited by practicalities, such as availability, the routes serviced by the line, and the types of vessels favoured by the shipping line. Costs also play a major role in this decision, although it is a highly competitive market, particular in terms of container shipping.

Logistics Documentation

Exporting fresh citrus requires thorough planning and attention to detail for every consignment. This is especially true for export documentation. If documents are missing, incomplete or incorrect, the consignment will definitely be delayed, compromising fruit quality, and may even be rejected. This can easily be avoided by knowing what is required and paying attention to the detail.

Some of the documents are the responsibility of the grower or the packhouse, some the export agent, some the logistics agent, and some the shipping line, but all play a vital role in the export process. Ultimately, it is the grower that stands to lose the most if there are delays or rejections due to documentation issues.

Export documentation requirements also change from time to time, and it is important to stay on top of the latest developments. Typically, the documentation required includes:

- Export Certificate
- Export Addendum
- Phytosanitary Certificate
- Customs Invoice
- Loading Instruction
- Export Notification
- Booking Confirmation
- Certificate of Origin
- Customs Declaration
- SARS SAD500, SAD507
- Cargo Dues Order
- Packing List
- Sea Waybill

Conclusion

Understanding the links in the logistics chain and, particularly, the cold chain for the fruit packed in your packhouse, is critical to successfully exporting citrus fruit and getting the best returns. There is much more to be said about the export supply chain, and we strongly recommend that you look at the Citrus Export Supply Chain short course, available from the Citrus Academy. We further recommend that you download and consult the Export Manual for the South African Fruit Industry, which is produced by the Fresh Produce Exporters' Forum.

Citrus Research International's Postharvest Technical Forum and Packaging Working Group is another handy source of information and advice on the requirements for citrus exports, and in particular about cold chain management.

We have now come to end of this series on Citrus Packhouses. We hope that you enjoyed learning more about citrus packhouse and postharvest supply chain operations, and that you found value in it. To learn more, please visit the Citrus Academy website, at citrusacademy.org.za. For useful resources, please visit the Citrus Resource Warehouse, at crw.org.za, where you will also find the Citrus Packhouse Best Practice Handbook.