Citrus Packhouse

Module 2:
Packhouse Infrastructure and Planning

Learner Guide

citrus academy
P.O. Box 461, Hillcrest, 3650
(031) 765-3410

citrus research international

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.

Scripted by:
Jacomien de Klerk

Visual material production:
Sagritex (Pty) Ltd

Additional information sources:
Citrus Research International

Project coordinator:
Citrus Academy (Jacomien de Klerk)

Produced by

In collaboration with

With the support of

Contents

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.