AMARTA Consultancy:
Vegetable Packinghouse Design for South Sulawesi

Dr. Lisa Kitinoja

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BACKGROUND (from the Scope of Work)

Agribusiness in Indonesia is changing for the better, pursuing new supply chain models such as hypermarkets, products and business structures. Yet Indonesian agribusiness must become even more dynamic to keep pace with the rapid transformation globally. At issue is not merely the ability of Indonesian products to compete in export markets, but the ability of Indonesian agribusiness to hold their own against foreign competition in the domestic market.

One of the obstacles facing Indonesian vegetable producers is the lack of vegetable packing plants to improve post-harvest handling and reduce production losses. The design and building of such packing houses will increase farmers' access to markets with added value horticulture products.

OBJECTIVES

The objective of this consultancy is to provide technical assistance to the Government of Indonesia Ministry of Agriculture Directorate General of Processing and Marketing for the Enrekang Sub-Terminal Agribusiness facility in South Sulawesi by providing packing house design and machinery recommendations. The purpose is to enable efficient utilization of the facility to assist farmers to access better markets with added value horticultural products.

TASKS (PERFORMANCE REQUIREMENTS)

The consultant will create a design for a vegetable packing plant for the Enrekang Sub-Terminal Agribusiness facility in South Sulawesi, and recommend appropriate machinery for the packing plant.

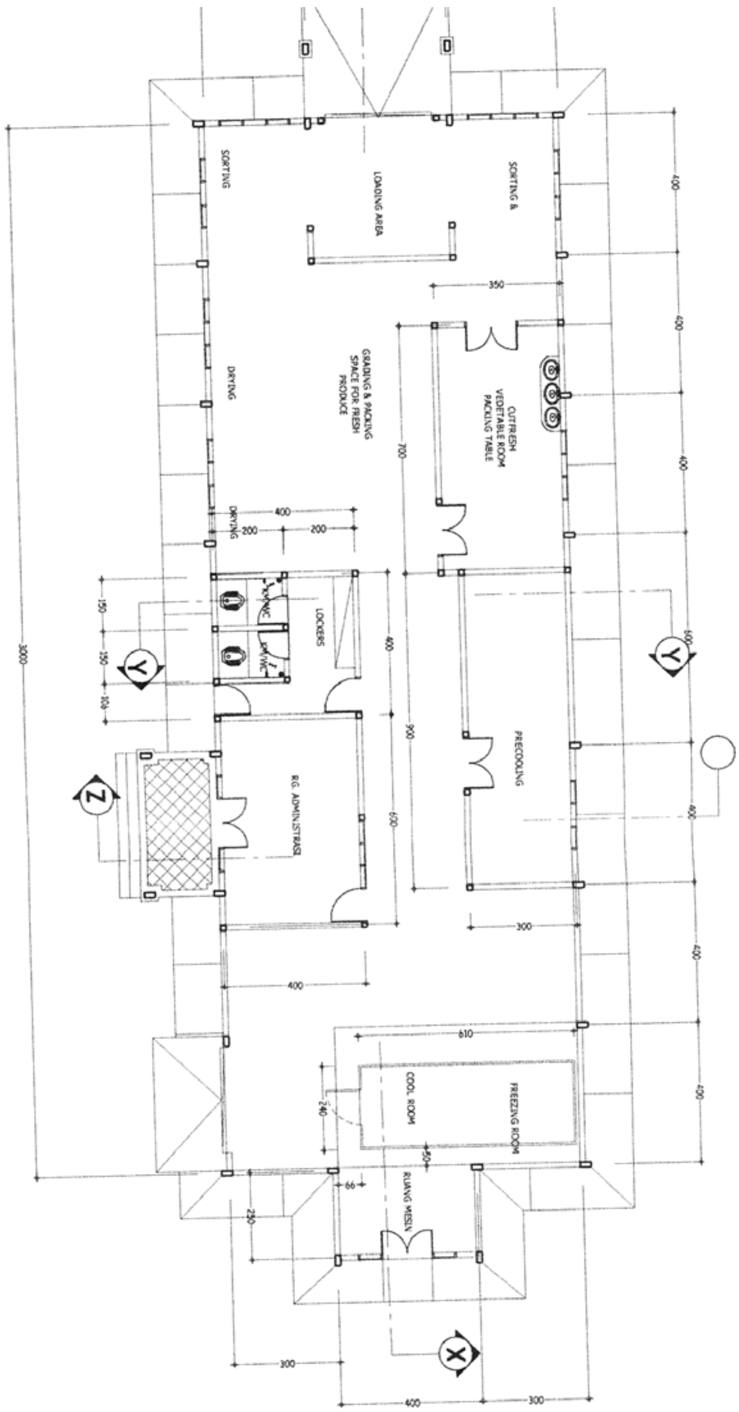
DELIVERABLES

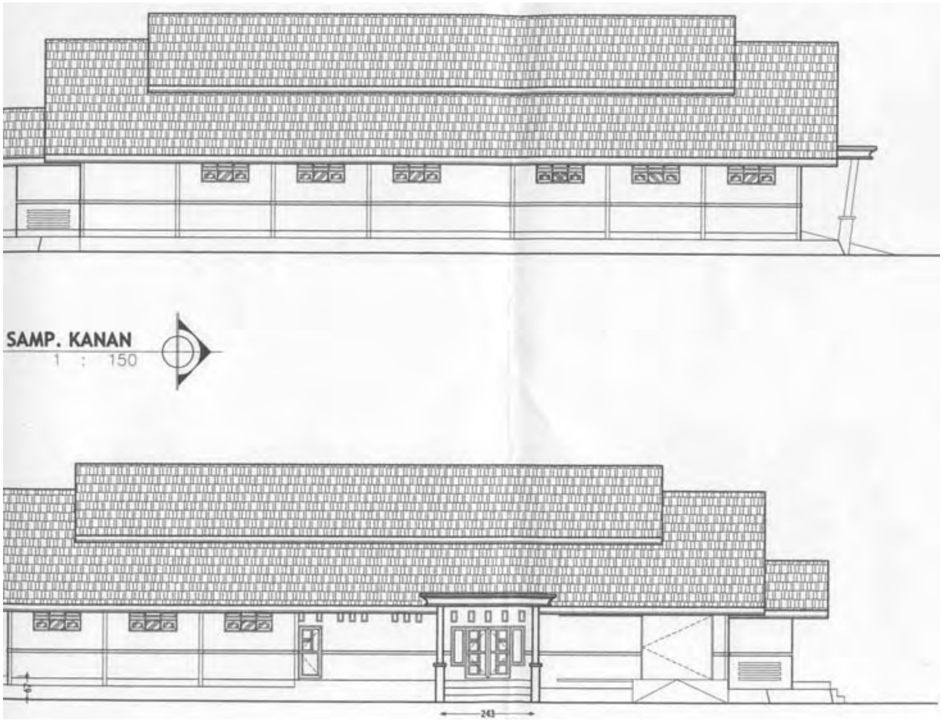
(1) Deliverable:	Design for a vegetable packing plant.	Required Delivery Date:	August 17, 2007*

*Note: Job contract was provided by Winrock International on August 22, 2007, and draft report was submitted on August 23, 2007.

I. REVIEW OF ORIGINAL PACKINGHOUSE DESIGN PLANS

The plan provided for the Sub Terminal Agro (STA) at Enrekang packinghouse exhibits several issues and problems that must be addressed before the structure will be suitable for packing and cooling fresh produce. The daily volumes intended to be handled within the new facility are too high for all the produce to be adequately pre-cooled before shipping, and the design provides cold storage capacity which is very low (providing space for approximately 10% of the peak volumes expected). The original plans are included in this document for reference, and improvements are suggested for a complete redesign within the report.





A. EXPECTED VOLUMES PER DAY

The following data of the types of produce expected to be Handled at Enrekang was provided by Dr. I Made Utama of Udayana University and Dr. Andi, head of the Department of Agriculture for Enrekang District. The table includes a list of the types of produce expected to be handled, as well as the estimated volumes per day during the three seasons encountered in South Sulawesi. Part A refers to produce that is to be shipped via road and delivered to cities on Sulawesi island, traveling to markets that vary in distance from 4 to 70 hours by road. Part B refers to deliveries intended for Kalimantan, a trip that takes 24 to 36 hours via land and sea.

Of the 14 commodities in the list, the two commodities of highest expected volume are cabbage (with a total of up to 82 MT/day) and spring onions (with a peak volume of approximately 15 MT/day) during January through June. The majority of these crops (approximately 75%) are intended for shipment to Kalimantan. Closely following in volume are tomatoes (10.4 MT/day) and shallot onions (10.4 MT/day) during the peak season. These four commodities account for nearly 85% of the total volume expected to be handled, with the other 10 commodities combining for the remaining 15%. It is recommended therefore that the packinghouse design should be oriented toward the optimal handling, packing and cooling of these 4 key commodities in order to ensure a successful venture.

Table of Expected Volumes

	Deliveries		Tons/day varying by Season		
A	Inter-city Sulawesi		Jan-June	July-Sept	Oct-Dec
			Puncak	Sedang	Rendah
	Commodity				
	Cabbage	Kubis	20.80	16.00	13.60
	Tomatoes	Tomate	10.40	8.00	6.80
	Onion/shallot	Bawang merah	10.40	8.00	6.80
	Chili	Cabe merah	3.90	3.00	2.55
	Carrot	Wortel	3.25	2.50	2.13
	Gourd	Labu siam	1.62	1.25	1.06
	Chinese cabbage	Sawi	2.86	2.20	1.87
	String bean	Buncis	2.60	2.00	1.70
	Potatoes	Kentang	2.60	2.00	1.70
	Spring onion	Bawang daun	1.95	1.50	1.28
	Celery	Seledri	1.30	1.00	0.85
	Caulifower	Bunga kool	0.19	0.15	0.13
	Red bean	Kacang merah	0.32	0.25	0.21
	Snake fruit	Salak	1.99	1.15	0.98
		Subtotal	64.18	49.00	41.66

B	Deliveries to Kalimantan		Tons/day varying by Season		
	Commodity		Puncak	Sedang	Rendah
	Cabbage	Kubis	61.10	47.00	39.95
	Spring onion	Bawang daun	13.65	10.50	8.93
		Subtotal	74.75	57.50	48.88
		Total	138.93	106.50	90.54

The calculations made to determine the requirements for handling these volumes have been done using one "pallet load" as a fixed unit, even though pallets are rarely used in Indonesia. It is a unit that is easy to visualize and fits well into the recommended various steps, such as pre-cooling, storage or transport. It is recommended that this model packinghouse move toward to use of pallet loads in order to 1) increase the number of packages that can be successfully handled per hour within a given space, and 2) to reduce the damage typically suffered by produce that is handled manually over the course of its journey through a packing facility. Every time a package is lifted and stacked or moved and restacked, the potential for rough handling is present. Palletization and subsequent movement of each pallet load via hand pallet jack is a simple and inexpensive way to limit the repeated impact damage that occurs whenever packages are moved from place to place.

Storage Potential Recommended Temperatures vs Ambient Temperatures

	Recommended Temp ºC	Potential Storage life		Estimated postharvest life at 20ºC		Estimated Postharvest life at 30ºC	*
Cabbage	0.0	20.0	weeks	5.0	weeks	2.5	weeks
Carrot	0	24	weeks	6	weeks	3	weeks
Potato	5	20	weeks	5	weeks	2.5	weeks
Cauliflower	0.0	3	weeks	1.0	weeks	4	days
Tomato	15.0	14	days	7	days	3	days
Chili peppers	10.0	20	days	10	days	5	days
Gourd	12.0	14	days	7	days	4	days
Salak	12.0	7	days	4	days	2	days
Spring Onions	0.0	21	days	5	days	3	days
Shallot onions	0.0	4	weeks	1	weeks	4	days
Chinese cabbage	0.0	8	weeks	2	weeks	1	weeks
Celery	0.0	4	weeks	1	weeks	4	days
String beans	7.0	7	days	4	days	2	days
Red beans	7.0	7	days	4	days	2	days

* postharvest losses would be expected to include weight loss, decay, yellowing of green vegetables, shriveling/water loss, development of bitterness (carrots, cabbages), textural changes (toughening, pithiness), over-maturity/over-ripening (tomatoes).

B. TYPES AND LOCATIONS OF LOADING DOCKS

The main loading dock for deliveries shows a ramp that allows vehicles (and their exhaust fumes containing ethylene gas) to drive up into the building. The partial wall provided to block off the ramp further complicates the efficient entry of produce into the facility and uses valuable space that could be used for pre-sorting and cleaning activities.

Loading docks are shown in positions on the building that would make truck drivers work more than necessary to turn their trucks around once inside the STA compound, and then back into position along the end and side of the building where space is limited along the peripheral fence lines. Instead, several easy in and easy out locations are available and are included in the suggested redesign.

C. WINDOWS AND ENTRANCES

Although three entries are shown on the original plan, the one on the far end, with stairs and visually appealing portico, is partially blocked by the cold storage unit. The administration office entry and placement of the offices and W/Cs effectively blocks one entire side of the building, making it difficult to lay out an efficient packingline.

The many windows provided in the original design are located in visually appealing locations, equally spaced around the outside of the building, but have no relationship to the function of the facility. Some of the windows are located where cold rooms need to be isolated form the outside. Most of the windows should be removed from the plans to minimize cost and reduce heat entry into the facility.

D. GENERAL LAYOUT AND KEY FEATURES

The rooms shown for fresh-cut processing and pre-cooling are oddly shaped for their purposes and doorways are located in positions that make smooth handling more difficult than it needs to be. In general, rooms are too narrow and there are too many corridors. Entries and exits to individual rooms should be located to make the flow of produce more efficient.

The size of the pre-cooling and cold storage room are not sufficient to handle the expected volume of produce. Using a 20 foot reefer container for a cold room may be of lower initial cost, but the space provided is small and difficult to access. Once produce has been loaded inside toward to front of the unit, the entrance is essentially blocked and removal of the first load is very difficult unless you unload the entire unit. These units are useful where cold storage rooms cannot be constructed from the ground up and a quick, ready made cold room is temporarily required, but for the purposes of this new facility, they are completely inadequate.

In addition, the placement of a single 20 foot reefer trailer inside an insulated room inside the facility will take up more space than necessary, make the workspace more noisy than is desirable and will require ventilation to remove diesel fumes if the refrigeration unit is to be powered by a generator (as might be needed in the case of a power failure). If these reefer units must be utilized for cold storage, it may be better to locate them outdoors under deep shade, and be able to use the interior of the facility for packing and pre-cooling.

II. RECOMMENDATIONS FOR IMPROVEMENTS IN DESIGN

A. LOADING DOCKS

- Instead of a ramp for the main loading dock for deliveries, a partially open loading dock is recommended. It should be wide enough for two vehicles to park at the same time, and should be completely covered so there is full shade on the dock.
- The dock should be wide and deep, so that it can be used for pre-sorting and cleaning activities along the back side, limiting the amount of soil and debris that enters the facility with commodities such as carrots, onions and potatoes.
- Loading docks are shown in positions on the building that would allow truck drivers to utilize easy in and easy out locations.

B. WINDOWS AND ENTRANCES

- The administration offices and main entry has been moved to one end of the building, making it easier to lay out efficient packinglines.

- Most of the windows should be removed from the plans to minimize cost and reduce heat entry into the facility. Walls should instead be constructed with a thick layer of insulation to reduce the overall heat load coming in through any walls that are exposed to sunlight.
- Screens need to be provided for any windows that open to the outdoors.
- Loading dock doors and doorways to cold rooms need plastic strip curtains to minimize the loss of cold and the entrance of flying insects.

C. PRODUCE FLOW WITHIN THE FACILITY

- For limited packinghouse operations such as those required for cabbage intended for Kalimantan markets, the loading dock could serve as the sole staging area for unloading, trimming and repacking into shipping containers, especially during times of the day when farm deliveries are not expected. If pre-cooling is not planned for the cabbage, the shipping vehicles could be loaded directly at the delivery dock, without having to move the produce through the packinghouse at all.
- The rooms shown for fresh-cut processing and pre-cooling have been re-shaped to better suit their purposes and doorways are located in positions that make smooth handling easier.
- Improved flow of produce within the facility is provided for in three ways: 1) the office and W/Cs have been moved to one end of the facility, 2) the entrances and exits to each room within the facility are located to allow people and produce to move easily in and out, with no cross traffic and 3) the suggested packinglines are laid out in straight lines.

D. GENERAL PACKINGHOUSE LAYOUT AND FEATURES

- The delivery dock will be an important feature, because much of the volume expected (cabbages, spring onions) may be able to be handled effectively (cleaned, trimmed, packed, loaded on to shipping vehicles) on this open dock. In addition, large washing and rinsing tanks located along the back wall of the delivery dock will be utilized for cleaning potatoes and carrots, thereby limiting the amount of soil and debris that enters the facility.
- Two packinglines are suggested— the first for potatoes and carrots (identified in the report and design options schematics as #1, located adjacent to the delivery dock and washing/rinsing tanks) and the second for all other commodities (identified as #2, and located adjacent to the pre-cooling rooms).
- The fresh-cut semi-processing room has been eliminated from some of the design options, since the volumes to be handled are so high that the facility cannot also provide the pre-cooling space that would be needed for such highly perishable items. Once the fresh intact commodities have been cut into pieces, their shelf life decreases from weeks to days or hours unless the product can be cooled immediately to 4C. Packing the fresh-cut items into the recommended containers such as small plastic tubs or polyethylene bags increases the cost of packing and cooling and also increases the amount of time and refrigeration capacity required for cooling. It is recommended that until workers in this facility gain experience with handling intact commodities, and demonstrate they can properly grade, pack and cool these products, plans for fresh cut semi-processing operations be put on hold.
- The size of the pre-cooler(s) and cold storage room(s) have been increased in size in most of the various design options so that they are more capable of handling the expected volume of produce.

- Options for cold storage in the new design options will be provided for 1) a simple insulated refrigerated cold room (highly recommended), and 2) either one or two 20 reefer units (not recommended for this facility, but acceptable if it is the only feasible option due to budgetary constraints).

E. SUGGESTED PACKING LINES

The commodities expected for the packinghouse, while compatible within three temperature zones for pre-cooling and cold storage, have very different kinds of postharvest handling requirements. The packing lines are designed to speed the handling steps while minimizing damage to the produce during handling and packing, using simple tools and equipment that will serve to take some of the drudgery out of the packing processes. Expensive equipment, such as electronic color sorters, weight sizers and automatic box fillers are a luxury rather than a necessity and have not been included in the equipment recommendations. For delicate vegetable crops, mechanical handling causes more damage than manual trimming and sorting, grading using simple tools or visual aids and packing by hand. The machines designed for these purposes are best used in countries where labor costs are too high to allow people to perform the manual tasks.

Use of trays for handling produce as it moves along the packinglines are highly recommended, since these will reduce rolling and decrease damage due to dumping, scuffing, bruising, scratches and bumps as produce is handled on the work tables and conveyor lines.

Illustration of Plastic trays

The packinglines are designed to use stainless steel tables as packing stations, and these same tables can be removed and rearranged whenever required to accommodate a variety of commodity handling operations. This flexibility will be important should new commodities be added to the mix in the future.

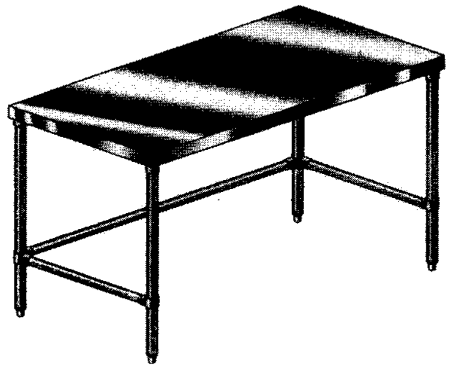


Illustration of a stainless steel table.

At the end of each packing line, it is recommended to use a gravity fed roller conveyor to move packed containers to the position within the facility where they can be palletized before further handling. Two weigh stations will be required—1) Weight should be checked within each container at the end of the packing line to prevent over or under packing and then 2) each completed pallet of produce can be weighed, labeled and recorded into a log before going on to pre-cooling or shipping.


Illustration of roller conveyor tables.

Line #1 (potatoes, carrots)

- Washing tank (on delivery loading dock)
- Rinsing tank (on delivery loading dock)
- Drying table with fans (inside facility)
- Grading/packing tables (recommended containers = 20 kg crates)
- Weighing station

Line #2 (all other produce)

- Initial wash (for spring onions to remove soil from roots)
- Dewatering station (for spring onions)
- Trimming tables (to remove by hand the outer leaves of cabbages, cauliflower, onions, to cut the excess leafy tops/ excess roots from celery, spring onions; to remove any leaves, stems and plant debris from beans, chilis; to cut salak fruits from bunch on stalk, etc)
- Washing/ roller brush dewatering equipment (for tomatoes and chili peppers only)
- Waxing/ hot air dryer (for salak, tomatoes and chili peppers, optional)
- Sizing /grading tools and equipment
- Packing stations (large tables with space for 4 to 6 workers)
- Conveyor belts
- Weighing station

F. **FORCED AIR (FA) PRE-COOLING STATIONS**

Proper management of the pre-coolers is key to preventing the buildup of packed produce in the packinghouse area where the temperature is higher than desirable for maintaining quality and obtaining long shelf life. Different crops will require longer or shorter pre-cooling periods, depending upon their arrival temperature, packaging materials used, and target temperature. Forced air cooling is the method chosen for use in this facility because it is the most widely adapted method, suitable for a wide range of fresh produce. Hydro-cooling, while well suited to some vegetables (such as carrots or potatoes), brings with it many management and food safety concerns, while the use of ice (for spring onions for example) is expensive and creates a mess as melting water runs off during handling and transport. Vacuum cooling may be suitable for some of the commodities, but the capital costs can be very high, and the incremental improvement over the forced air method is usually not worth the added expense.

Containers must have holes for ventilation which align when stacked side by side in order for forced air cooling to provide optimal cooling to the produce inside the containers. Most plastic crates have these vent openings on both the ends and the long sides of the container, so proper alignment should be simple and not create any management problems. If the facility plans to move toward the use of fiberboard cartons in the future, proper venting (5% per side) and proper alignment of cartons during pre-cooling is critical for success in the FA pre-cooling rooms.

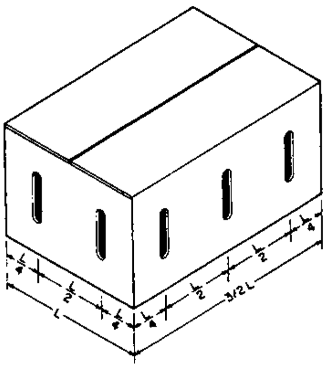


Illustration of proper venting in a carton—vents align whether the cartons are placed side to side, end to end or side to end to make up a pallet load.

The design options provided in this report are for either one or two pre-cooling rooms, each with one or two "stations" where a forced air cooling tunnel can be set up inside the room. The optimum selection would be for the option of one large pre-cooling room, 4m x 9m in size, holding two 6-pallet forced air cooling stations at any single target temperature and one smaller pre-cooling room (for one FA station), which will allow for cooling using three cooling stations. In this case the pre-cooling rooms can cool to two different target temperatures during the same time period. In both cases, each station, also known as a forced air cooling tunnel, can be set up and operated independently, which will save energy and make temperature management easier for the managers of the facility.

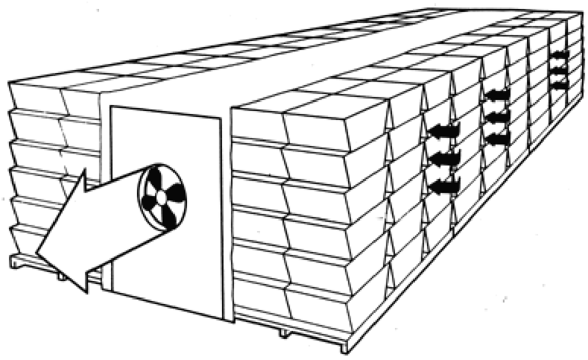
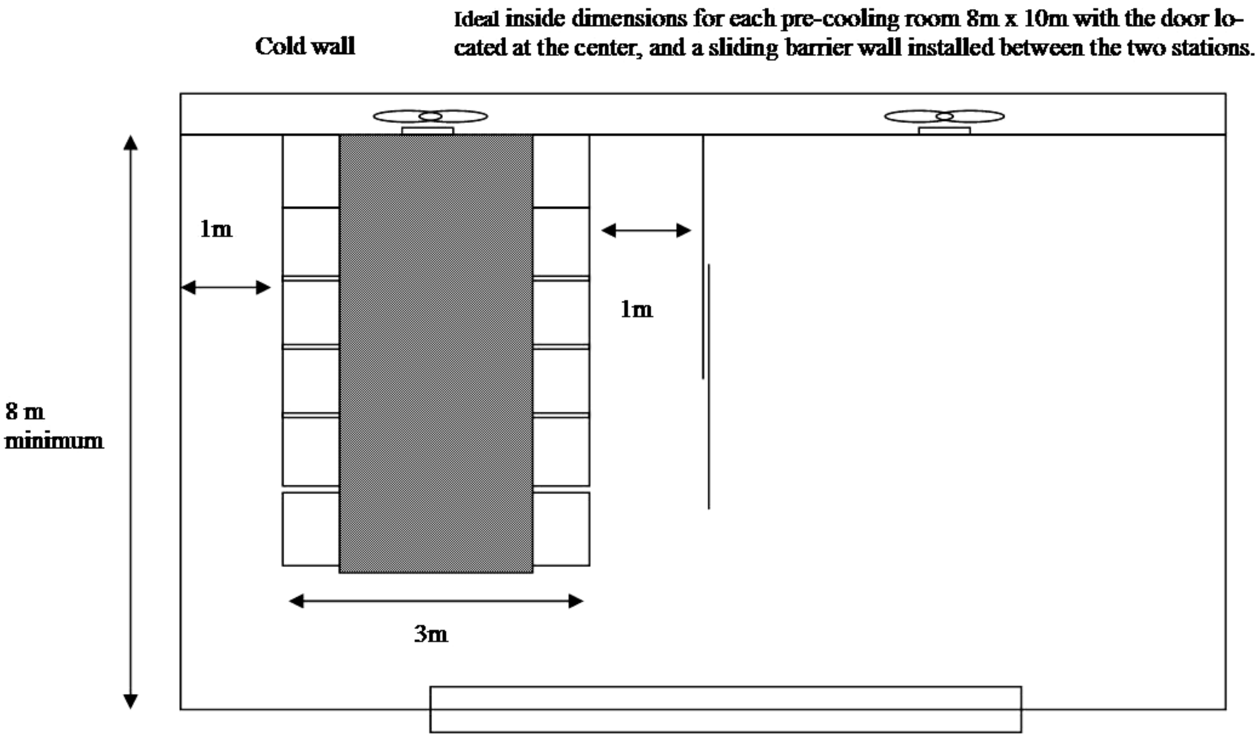
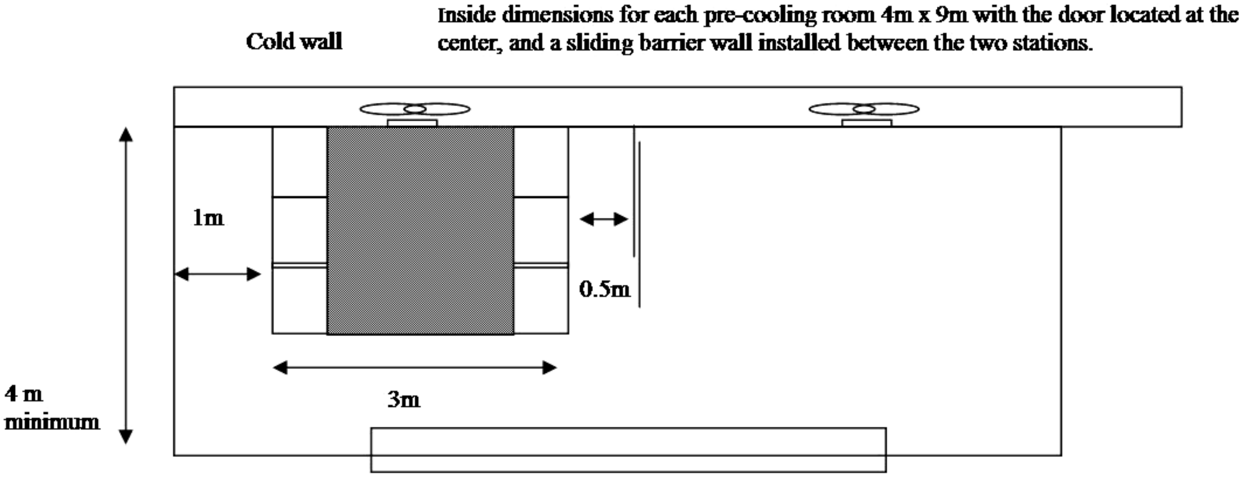


Illustration of a large FA tunnel. The center of the two rows of 4 pallets is covered by a heavy cloth, creating a space about 1 meter wide for air to be drawn into the load from inside the pre-cooling room. The fan, in this illustration, is located separate from the cold wall, but the fan can also be built into the cold wall along the side of the pre-cooling room (recommended).

Ideal size of pre-cooling room if the space is available in the packinghouse facility:



Size of pre-cooling room that can be accommodated in this facility:



G. COLD STORAGE ROOM OPTIONS

The various design options provide for either one or two separate cold rooms that will allow the facility to provide temporary cold storage. If only one cold room is included in the facility, then only a single temperature can be maintained. However there are three different temperature zones required for the mix of commodities expected to be handled in this facility. In addition, many of the commodities produce strong odors, which might be absorbed by other produce held nearby during cooling or shipping. Ideally there would be separated pre-cooling and cold storage space provided for each commodity group, plus extra space for those commodities that can make problems for others (mainly to minimize the spread of onion, pepper or earthy potato odors).

If the two cold rooms option is selected, each cold room can be operated independently and provide any desired temperature within the range of 2C to 10C. Colder temperatures (0 C) are recommended for long distance transport or long term cold storage of cabbage, carrots, onions, celery and cauliflower, but the cost maintaining this very low temperature in Indonesia is so high that it is usually not economically feasible for these low value crops.

The 14 commodities to be handled in the STA facility have been grouped below in a compatibility table, according to their required temperatures for optimal pre-cooling and short term cold storage. There are three different groups of commodities to be considered, according to their differing temperature requirements. A single cold room, such as included in the original plans, would be useful only if a single group of compatible commodities were being cooled and stored in a given period of time.

Ideally two cold rooms would be included in the packinghouse design, but in this case the space available is very limited. One possibility would be to build a self contained cold room inside the facility and then to add additional temporary cold storage as needed by placing 20 ft reefer units somewhere outdoors under deep shade.

Compatibility of fresh produce recommended to be handled in the vegetables packinghouse/ pre-cooling/ cold storage facility:

	0 to 2 C	4 to 7 C	10 to 15 C
Vegetables Ethylene sensitive	Cabbage Chinese cabbage *Spring onions Carrots *Shallot onions Celery Cauliflower	Green string beans Red beans *Potatoes	Gourds *Hot chili peppers
Fruits or Fruit-Vegetables Ethylene sensitive and ethylene generator			Salak Tomatoes

* odors generated by these strong smelling commodities will be absorbed by neighboring commodities so care should be taken to separate odiferous crops from the rest of the mixed load whenever storage is required for more than a few hours.

H. SIZE REQUIREMENTS FOR FACILITY FEATURES BASED UPON EXPECTED VOLUMES

Only the peak season has been considered when making these calculations, since if the facility can handle the commodities successfully during the days with highest expected volumes, then at other times of year the capacities will be within the necessary parameters.

Table of total volumes for each commodity expected during peak season

Enrekang STA	Peak Tons	# 20 kg containers per day	40 containers per pallet # pallets per day	10 pallets/ truckload # truckloads per day	cold storage space req'd per day (1 m sq/pallet) Meter sq	20 ft reefer equivalents
Cabbage	81.90	4095.00	102.40	10.20	102.40	10.20
Carrot	3.25	163.00	4.10	0.40	4.10	0.40
Potato	2.60	130.00	3.25	0.30	3.25	0.30
Cauliflower	0.19	10.00	0.25	0.03	0.25	0.03
Tomato	10.40	520.00	13.00	1.30	13.00	1.30
Chili	3.90	195.00	4.90	0.49	4.90	0.49
Gourd	1.62	81.00	2.00	0.20	2.00	0.20
Salak	2.00	100.00	2.50	0.25	2.50	0.25
Spring Onions	15.65	782.50	20.00	2.00	20.00	2.00
Shallot onions	10.40	520.00	13.00	1.30	13.00	1.30
Chinese cabbage	2.86	143.00	3.60	0.36	3.60	0.36
Celery	1.30	65.00	1.60	0.16	1.60	0.16
String beans	2.60	130.00	3.25	0.30	3.25	0.30
Red beans	0.32	16.00	0.40	0.04	0.40	0.04
Total	139.0	6950.5	174.3	17.3	174.3	17.3

It is obvious from the start that the amount of cold storage space provided for in the original design (the equivalent of one 20 foot reefer unit) is not nearly adequate for holding the expected volumes of commodities. Even if cabbage was removed from the daily total, more than 7 times this amount of space (enough for over 70 pallet loads) would be needed for temporary cold storage during the course of one day. There is simply not enough time to move so much produce in and out of cold storage before shipping, so most produce would simply have to be shipped immediately after packing.

In two of the worst case scenarios, many truckloads of vegetables could be delivered, packed, then be forced to stand by at ambient temperature inside the facility because the pre-coolers were already full. Or if the produce could be pre-cooled and was ready to ship, while vehicles were delayed or loading was slowed down by bad weather or limited worker availability—where then would all this cooled produce be held? The expense of pre-cooling would be largely wasted if the product was allowed to re-warm as it sat inside the ambient temperature packinghouse or on the dock while waiting to be loaded for transport.

Once the pre-cooling capacities that are expected to be needed for the various commodities are taken into consideration, it is even more apparent that the facility design is undersized in the original plans. The 14 commodities expected to be handled in this facility have been re-grouped in the following table into categories that best fit their temperature requirements. The initial incoming produce temperature of 30C is an estimate based upon typical temperatures in South Sulawesi during the peak season. If the initial temperature of the produce is lower at delivery (such as for produce harvested very early in the morning and kept in the shade) pre-cooling will take somewhat less time. If the delivery temperature is higher than 30C (such as for produce left in the sunshine or produce shipments that have been delayed for many hours after harvest before delivery to the packinghouse), then pre-cooling will take longer than shown in the table.

Estimated Pre-cooling Rates (Forced Air Tunnels)

Average Cooling rates	Starting Temp.	Target Temp.	1 L /sec/kg FA flow rate Estimated Hours per 1/2 cooling cycle	Estimated Hours to 7/8ths cool
Group A				
Cabbage	30	2	4	12
Carrot	30	2	4	12
Potato	30	5	4	10
Cauliflower	30	2	4	12
Group B				
Tomato	30	15	2	6
Chili	30	12	1	3
Gourd	30	12	2	6
Salak	30	12	2	6
Group C				
Spring Onions	30	2	1	3
Shallot onions	30	2	2	6
Chinese cabbage	30	2	2	6
Celery	30	2	2	6
Group D				
String beans	30	7	1.5	4.5
Red beans	30	7	1.5	4.5

Group A is expected to take a very long time to pre-cool using FA cooling, and therefore pre-cooling before shipment via FA is not recommended for these crops. Long distance shipment via reefer truck will provide a small amount of cooling to occur during transport, but only if the vehicles are not over-loaded, and only if the produce is packed in vented containers that can be stacked and braced to allow air to get through the load during transport.

Estimated Total Pre-cooling Time Requirements

	Peak # 6 pallet loads per day	Total FA Cooler hours required	Notes
Group A			
Cabbage	17	204	Group A
Carrot	0.7	8.2	bulky commodities of relatively low value
Potato	0.5	5.4	very slow FA cooling rates
Cauliflower	0.04	0.5	FA not recommended
Sub-total	18.24 loads	218 hours/day	
Group B			Group B
Tomato	2.2	13.2	chilling sensitive commodities,
Chili	0.8	2.4	very gentle handling required
Gourd	0.3	1.8	waxing can increase potential postharvest
Salak	0.4	2.4	life, but only if produce can be kept cool
Sub-total	3.7 loads	19.8 hours/day	
Group C			Group C
Spring Onions	0.4	1.2	smaller size produce will cool faster than bulky produce; pre-cooling will greatly
Shallot onions	2.2	13.2	decrease losses from water loss and decay
Chinese cabbage	0.6	3.6	
Celery	0.25	1.5	
Sub-total	3.45 loads	19.5 hours/day	
Group D			Group D
String beans	0.5	2.25	too rapid cooling may lead to high water loss; pre-cooling will greatly decrease
Red beans	0.06	0.27	losses from water loss and decay
Sub-total	0.56 loads	2.52 hours/day	

The number of pre-cooling loads (6 pallets each) of commodities from Groups B, C and D during peak season adds up to approximately 8 loads per day. The commodities in these three groups can be pre-cooled in 6 hours or less, allowing each tunnel to handle at least 2 loads per shift.

The following table shows how two FA cooling tunnels can barely accommodate this volume, and can do so only if the facility is operated 24 hours per day (during two 12-hour shifts). A more appropriate design may be to include space for 3 FA tunnels, so that at least during non-peak days or seasons, the packinghouse could plan to operate during only one shift. An added advantage of having three FA tunnels would be the ability to pre-cool to two different target temperatures at the same time. If only one temperature zone is possible, then some produce may be left waiting to begin cooling until after all the first temperature zone loads have been pre-cooled. In the case of this facility, with three different groups commodities each with a different target temperature (12, 7 or 2C), it is highly likely that some produce would be sidelined while the pre-coolers were being utilized at an unsuitable temperature.

The benefits of housing three separate FA tunnels in three separate rooms, while substantial (all three groups of produce could be cooled simultaneous to their desired temperatures) most likely would not be cost effective. The cost of an additional refrigeration system makes the potential economic benefits questionable. It is recommended that the chilling sensitive produce Group B) be the group to undergo the delay if there is a need to sideline produce before pre-cooling.

Pre-cooler Use Estimates

Maximum # loads/day (12 hour shifts)
Average of 6 hours per load

1 shift 2 tunnels 1 temp zone	2 shift 2 tunnels 1 temp zone	1 shift 3 tunnels 2 temp zones	2 shifts 3 tunnels 2 temp zones
4	8	6	12

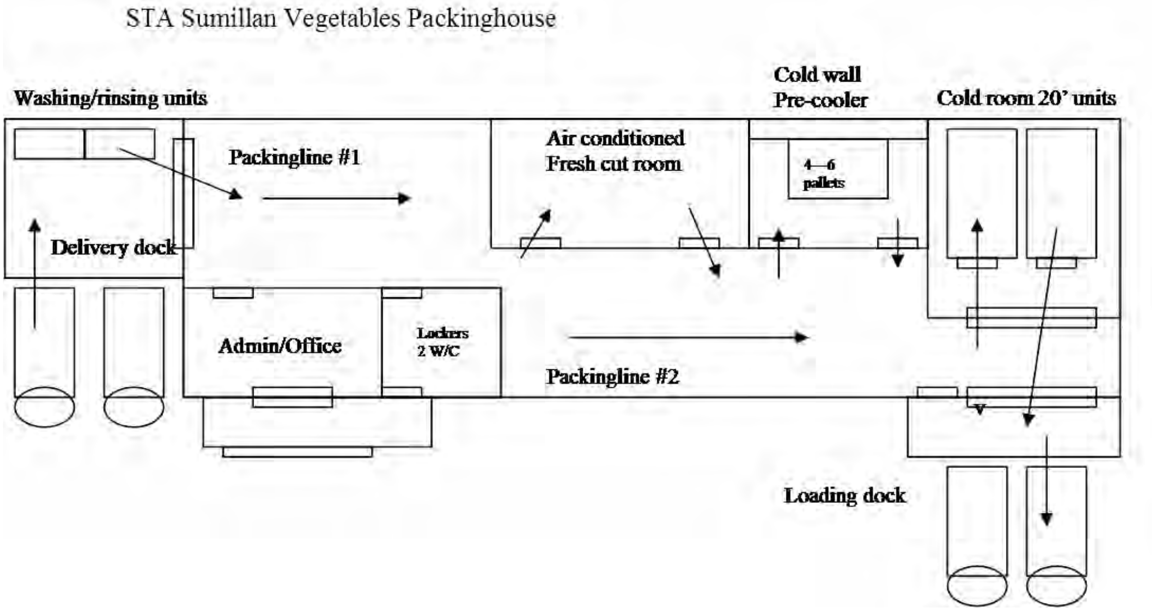
I. FOUR OPTIONS FOR IMPROVED DESIGNS

The proposed design options for the STA Enrekang facility is shown below. Four slightly different options are provided, and the choice made will depend upon desired primary use of the facility (packing intact produce vs manufacturing fresh cur semi-processed vegetable products) and the volume and type of produce that needs quick cooling (depending upon target markets). While it is recommended that all fresh produce be pre-cooled whenever possible, prioritization may be required if capacity is limited. Most export markets, for example, demand pre-cooling, while pre-cooling for some domestic markets may be less critical due to their relative closeness.

The placement of the packinglines, pre-cooling and cold storage areas has been done to my personal preferences, but any layout that would streamline handling and reduce cross traffic movement could be considered.

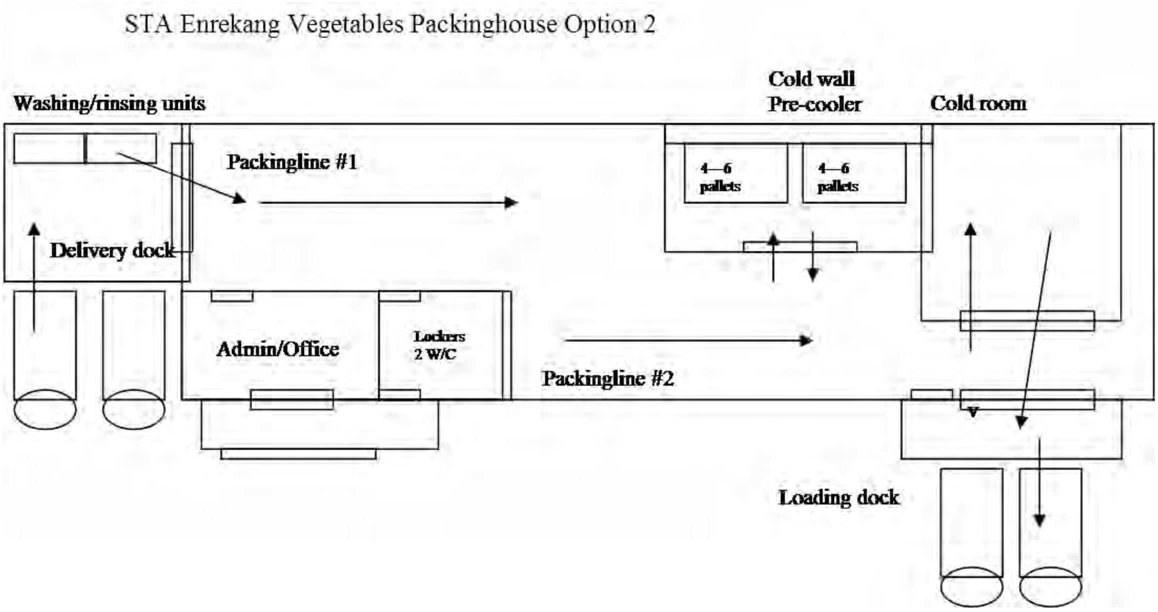
Option 1 includes all the packinghouse features that were in the original design, and eliminates one entrance (the one that was partially blocked by the cold room). Two 20 foot reefer units are included rather than the one shown in the original design. The spaces available for packinglines are wider than in the original design, there are fewer corridors, and all of the doorways have been moved to enhance produce flow. The delivery dock contains washing and rinsing tanks at the back side and has enough work space to allow some produce handling/packing on the dock itself (recommended for cabbage intended for the Kalimantan market). Overall design option #1 appears cramped, and the size of the space available for the two packinglines and pre-cooling is insufficient to handle to expected volumes.

Design Option 1:



Design Option #2 provides more space for pre-cooling, by removing the fresh-cut semi-processing room. It also provides for a large working space on the delivery dock. One of the major features is a single large cold room (approximately 7m by 8m), easily accessible to the loading dock. Loading the vehicles by taking pallet loads from the cold room would be streamlined and very quick. With a separate cold room such as in this design, it is possible to stack produce higher than one pallet load high, potentially doubling the cold storage capacity. Additional cold storage space for a second temperature zone could be added easily by placing a temporary reefer unit outdoors under deep shade (adjacent to the loading dock along the outside wall where packingline #2 is situated).

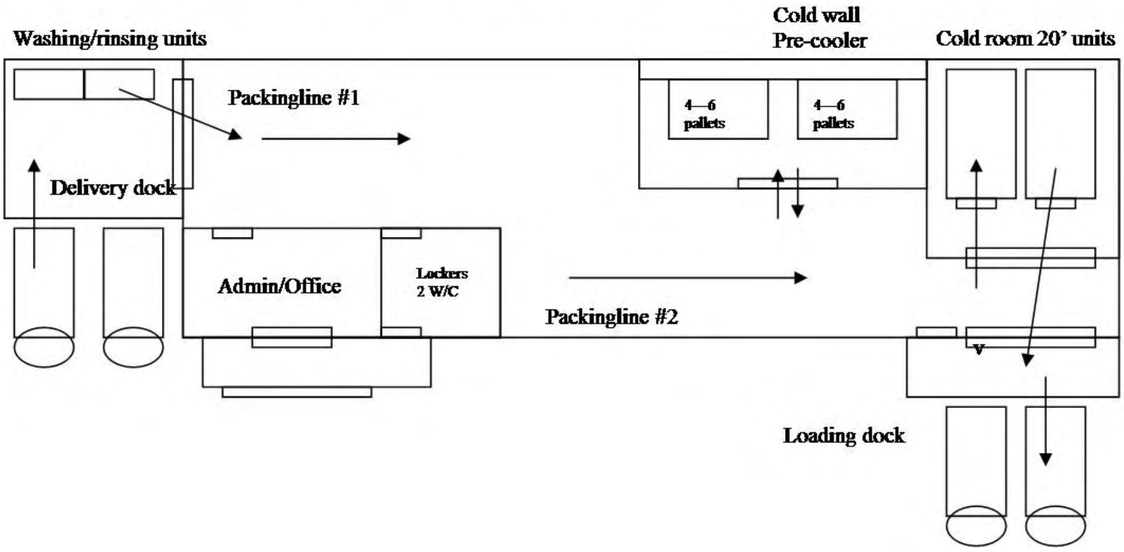
Design Option 2:



Design Option #3
The third option combines some of the features of option #1 (two reefers provided for cold rooms, so that two temperature zones can be maintained at any given time) and option #2 (a large pre-cooling room with two FA tunnels). Again the fresh-cut processing room has been eliminated to provide space for packinglines and cooling operations, and the delivery dock is a large working space.

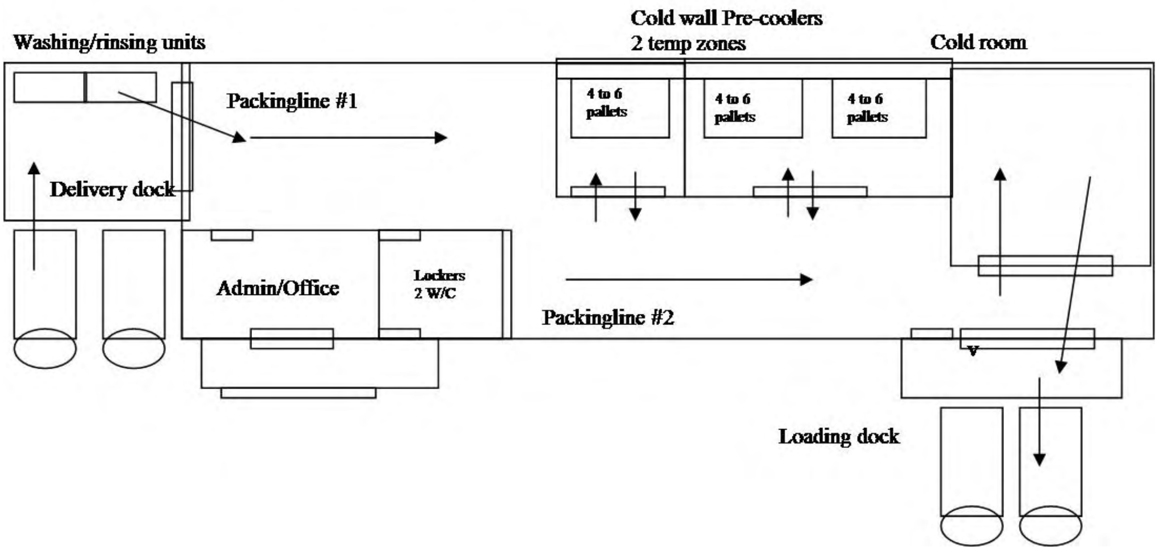
Design Option #3

STA Enrekang Vegetables Packinghouse — Option 3



Design Option #4:
This design option provides the most pre-cooling capacity (in two rooms each with its own temperature zone) as well as a large cold room (approximately 7m by 8m). With a separate cold room such as in this design, it is possible to stack produce higher than one pallet load high, potentially doubling the cold storage capacity. Additional cold storage space for a second temperature zone could be added easily by placing a temporary reefer unit outdoors under deep shade (adjacent to the loading dock along the outside wall where packingline #2 is situated).

STA Enrekang Vegetables Packinghouse — Option 4



All of these options are limited by the size and shape of the original design, given that the facility must fit on the land provided in the STA compound. It is expected in all cases, that most of the produce that runs through the STA facility will of necessity be handled and packed, then shipped without pre-cooling or cold storage. If these postharvest practices are desired for the total volume of produce during peak season, then a facility 3 to 4 times larger will be required.

Ideally the option selected would be based upon cost considerations, as well as an understanding of the intended markets, beginning with both the expected volumes that are predicted to be run through the facility and on knowledge of prevailing market conditions. For example, if there was money to be made by fresh-cut processing and pre-cooling produce for local supermarkets, the highest value and/or the most highly perishable produce would be run through the semi-processing rooms and pre-coolers and then shipped immediately. If it was known there was usually a premium being paid for a given type of produce when it was coming into or going out of season, or because less than usual was available due to weather or supplier problems, then that produce could be pre-cooled and placed into temporary cold storage to be able to take advantage of the higher market prices. In this case more cold storage room would be desirable, with the temperature zone suitable for the type of produce of high value.

III. SPECIFIC RECOMMENDATIONS FOR POSTHARVEST HANDLING PRACTICES

A. HARVESTING PRACTICES

To begin with, good basic postharvest handling practices should be stressed, including the use of harvest indices to ensure that the produce is harvested at proper maturity. Proper tools should be used to harvest produce, and tools should be kept clean and sharp.

One of the most common mistakes growers make is to harvest crops too early or too late, when they are under-developed or over-developed and not at the peak of their full flavor. With many horticultural crops, if you harvest all at once you are sure to have many items that are either under-mature or over-mature, too large or too small. Using a maturity index as a standard will greatly reduce pre-sorting losses.

Mechanical damage during harvest can become a serious problem, as injuries predispose produce to decay, increased water loss and increased respiratory and ethylene production rates leading to quick deterioration. The containers used by pickers in the field should be clean, have smooth inside surfaces and be free of rough edges. Stackable plastic crates, while initially expensive, are durable, reusable and easily cleaned. If baskets must be used, they should be woven "inside out" with the stubs of the beginning and end of each cane left on the outside of the basket.

Whenever possible, vented, stackable plastic crates should be used to collect produce in the field, avoiding the damage caused when using the traditional local baskets of enormous size. Estimates by vegetable producers and marketers are that 50% of the produce will be sub-standard, mostly due to surface damage and the beginning of shrivel or evidence of partial decay, so fresh cut processing should be considered as a supplementary activity within the operation.

Manual harvesters should be well trained in the proper way to harvest each crop to minimize damage and waste, and should be able to recognize the proper maturity stage for the produce they are handling. Pickers should keep their fingernails trimmed and learn to harvest with care, cutting, clipping or pulling the fruit from the plant in the least damaging manner. Knives and clippers should always be well sharpened and kept clean. Removing jewelry before harvesting can help limit damage to vegetables form inadvertent gouges and cuts. Pickers should be trained to empty their picking bags and/or containers with care, never dumping or throwing produce into field containers.

Exposure to the sun should be avoided as much as possible during and after harvest, as produce left out in the sun will gain heat and may become sun-burned. Produce exposed to sunlight can soon become 4 to 6 °C (7 to 11 °F) warmer than air temperature. Field bins should be placed in the shade or loosely covered (for example with light colored canvas, leafy plant materials, straw or an inverted empty container) if delays are expected in removing them from the field. Night or early morning harvest is sometimes an option for harvesting produce when internal temperatures are relatively low, reducing the energy needed for subsequent cooling.

B. VENTED PLASTIC CRATES

According to Dr. Utama, packages used currently for packing and transport are generally inadequate to protect produce and minimize damage from rough handling and overloading of vehicles. Some of the cabbage loads sent to Kalimantan currently get no packaging at all, and are merely stacked inside the vehicles in bulk loads. Net bags, plastic sacks or baskets provide little or no protection from crushing during transport, and can block air flow, limiting the cooling potential inside a cold truck.

Wooden crates are much better packages-- but only if they are not over-filled before stacking. For the purposes of this desk study, vented plastic crates will be used as the unit package, holding either 20 kg of produce. In reality, crates holding 5kg or 10 kg are more suitable for delicate vegetables (peppers, spring onions, etc) and fruits such as ripe tomatoes or salak.

C. TRANSPORT OF PRODUCT TO PACKINGHOUSE

Rough handling during preparation for market will increase bruising and mechanical damage and limit the benefits of cooling. Roads between the field and the packinghouse should be graded and free from large ruts, bumps and holes. Field containers must be well-secured during transport and, if stacked, they should never be over-filled. Transport speeds must be suited to the quality and conditions of the roads, and truck and/or trailer suspensions kept in good repair. Reduced tire air pressure on transport vehicles will reduce the amount of motion transmitted to the produce, and therefore reduce bruising during transport.

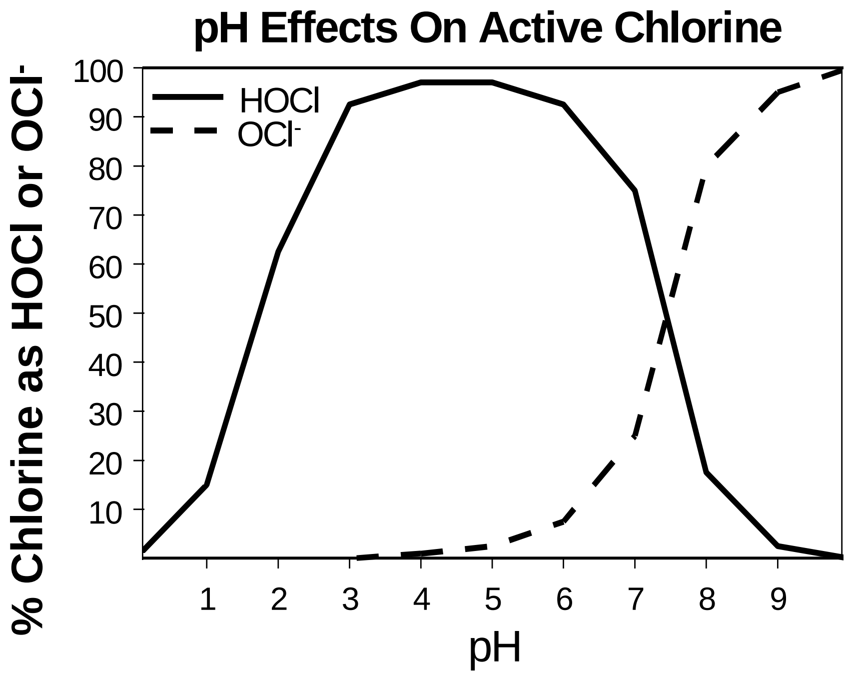
D. PACKINGHOUSE WATER SANITATION

Inadequate sanitation of packinghouse wash water is very common in Indonesian facilities. This includes a lack in frequency in changing the water in the tanks, along with little or no monitoring of the chlorine concentration and pH of the water over time. Submergence or spraying fresh produce in un-sanitized water contaminated with bacterial and fungal pathogens will significantly increase the likelihood of postharvest decay showing up a few days after packing. This is even more likely to occur if the produce is injured or wounded. Also, if partially decayed produce is put into the wash tank with the marketable products, inoculation of the healthy products with microbial spores commonly occurs, followed a few days later by symptoms of postharvest decay.

Due to the time lag between infection and symptom development, many packers do not understand the dangers of exposing fresh produce to un-sanitized water. They do not see the decay symptoms that appear during product distribution or marketing, but these will result in price adjustments and lower returns to the seller. In addition, those who develop the reputation for having arrival quality and decay problems on their commodities run the long-term risk of losing their market to suppliers who can provide higher quality produce.

Chlorination of wash and rinse water is very important. Chlorine use can reduce the spread of contamination from one item to another during the washing stage. The pH of the wash water should be maintained at 6.5 to 7.5 for best results.

Typically 1 to 2 mls of chlorine bleach per liter of clean water will provide 100 to 150 ppm total Cl. More chlorine will be required if temperatures are high or if there is a lot of organic matter in the wash water.



As more produce items are added to the wash water, the concentration of free chlorine will decrease. This is the result of soil particles, dirt, debris, and the produce itself lowering the chlorine concentration as it is used up over time. If the same wash water is being re-used for extended periods of time, regular monitoring of the free chlorine level in the water is required. Checks should be made on an hourly basis.

Simple test strips and color test kits are available for determining chlorine concentration. Wash water pH can be checked using litmus paper and liquid test kits, but the simplest way is to use a digital pH meter which takes an instant reading of the water pH. The water pH should always be checked at the same time as the chlorine is monitored. If the water pH is measured to be above 7.0, it can easily be lowered by adding a small amount of vinegar or citric acid. If the water pH is below 6.5, it can be raised by adding a small amount of lye (NaOH). These additives are readily available and are very low cost.

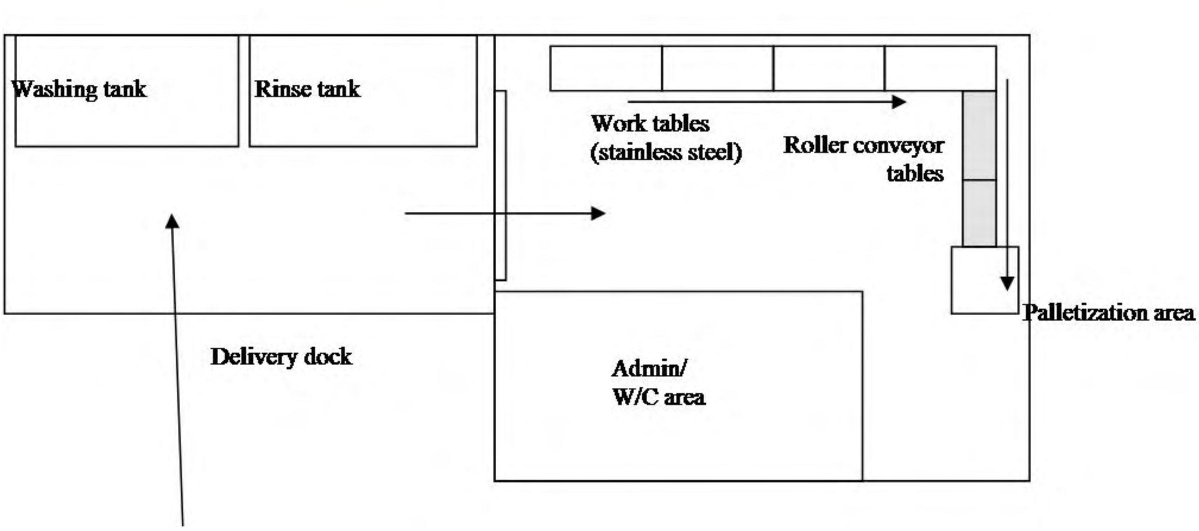
Several water testing and chemical supply companies in the USA sell pH and chlorine monitoring devices (see Appendix A).

E. FACILITATION OF PRODUCE FLOW WITHIN THE FACILITY

Any time produce must be dumped, handled, repacked, moved, stacked or unstacked there is a potential for causing damage. A well designed packinghouse facility will be laid out in the most efficient ways, eliminating as much as possible any cross traffic and bottlenecks. These design options provide for linear produce flow on each packingline, and requires no movement against the flow once the produce enters the packinghouse. Use of gravity fed conveyor tables to move packed containers will greatly reduce the need to lift and stack containers more than once, therefore reducing the chance of incurring handling damage.

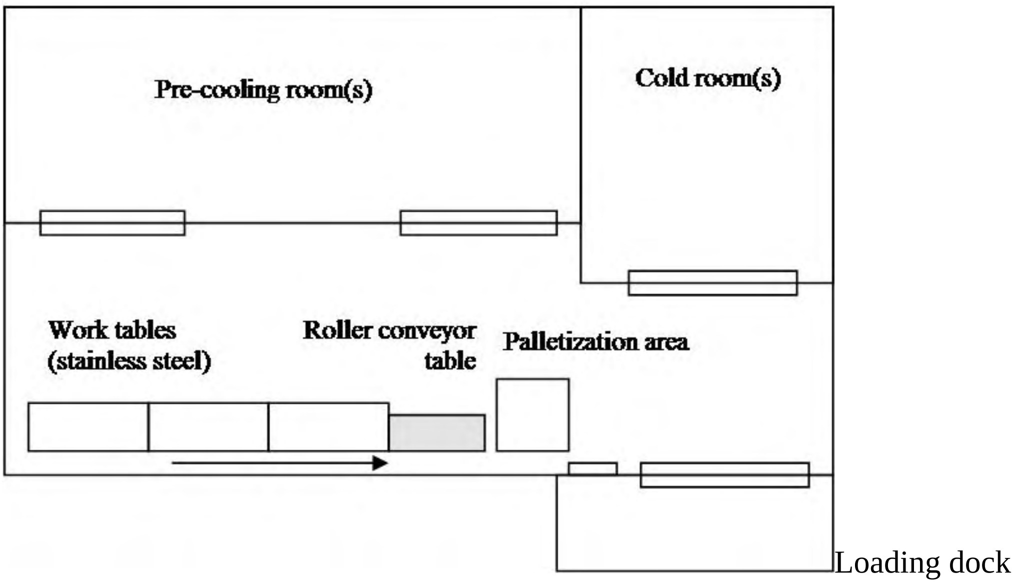
Packingline #1:
If the work tables are arranged along one wall, they can be used either along one side, or by moving them away from the wall, on both sides at one time. Each 2 meter long table can accommodate up to 3 workers per side.

Packingline #1 layout



Packingline #2:
If the work tables are arranged up against the wall, they can be used along one side, or by moving them away from the wall, they can be used on both sides at one time. Each 2 meter long table can accommodate up to 3 workers per side. If an automated washer/waxing machine is desired, it can be placed at the beginning of this packingline.

Packingline #2 layout



F. CLEANING/ WASHING OR TRIMMING

Each type of produce expected to be handled in this facility requires a different kind of cleaning or trimming before packing. There are washing/rinsing tanks located out on the main delivery docks and the packinglines provide a series of wide, clean tabletops to make the various tasks easier. Providing good quality lighting and padded flooring mats will make the jobs easier to do for the workers.

Many different cleaning/trimming steps are required:

	Wash	Rinse	Trim	Other
Potatoes	May need scrubbing to remove soil	Chlorinated rinse water required		
Carrots	May need scrubbing to remove soil	Chlorinated rinse water required	Remove leafy tops	Remove or trim root hairs
Cabbage			Remove outer leaves	Treat butt end with alum to prevent decay
Tomatoes	Use water warmer than fruits to prevent decay	Chlorinated rinse water required		Instead of washing can clean using soft cloth, add wax if

	Wash	Rinse	Trim	Other
				desired
Onion/shallot			Remove outer dry scaly tissue	
Chili	Use water warmer than fruits to prevent decay	Chlorinated rinse water required		Instead of washing can clean using soft cloth, add wax if desired
Gourd				Trim cut stem end if req'd
Chinese cabbage			Remove outer leaves	Treat butt end with alum to prevent decay
String bean	Never wash beans			
Spring onion	Wash soil from roots	Chlorinated rinse water required	Cut excess roots away, trim leafy tops to uniform length	
Celery			Cut excess roots away, trim leafy tops to uniform length	
Cauliflower			Remove outer leaves	
Red bean	Never wash beans			
Snake fruit				Remove scaly surface tissue using soft cloth, add wax if desired

G. SORTING/GRADING/PACKING/WEIGHING

All of the sorting and grading that will be done in this facility is expected to be done manually, using simple hand tools and references. Please refer to section J below for more details. Two weighing stations are required—the first to check weigh each container as it is packed, and the second to weight each pallet load of produce before it is shipped.


Illustration of a check weighing scale

Illustration of a pallet weighing scale with ramp.

H. PALLETIZATION

It is recommended that this model packinghouse move toward to use of pallet loads in order to 1) increase the number of packages that can be successfully handled per hour within a given space, and 2) to reduce the damage typically suffered by produce that is handled manually over the course of its journey through a packing facility. Every time a package is lifted and stacked or moved and restacked, the potential for rough handling is present. Palletization and subsequent movement of each pallet load via hand pallet jack is a simple and inexpensive way to limit the repeated impact damage that occurs whenever packages are moved from place to place. Should the decision be made for handling be done without pallets in the new facility, it will increase the time required to move produce along from step to step, but will not affect the times estimated for pre-cooling or the temperature effects expected during transport-- unless the cold rooms or vehicles are over-loaded.

I. FRESH CUT PROCESSING

Typically in developing countries, up to 40% of fresh produce is not suitable for long distance markets, and fresh-cut processing is one way to create value addition for this otherwise cull material. The cost of setting up a fresh-cut room is quite high, since it needs to be kept cool (4 to 5C) and be able to maintain in a sterile environment (this is made easier by using stainless steel equipment and work tables). Estimates of initial cost usually match those of a cold room of the same size and dimensions.

The fresh-cut semi-processing room has been eliminated from some of the design options, since the volumes to be handled are so high that the facility cannot also provide the pre-cooling space that would be needed for such highly perishable items. Once the fresh intact commodities have been cut into pieces, their respiration rates increase and their potential shelf life decreases greatly (from weeks to days for produce such as carrots or cabbages, or from days to merely hours for beans or spring onions), unless they can be cooled immediately to 4C. In the case of this facility, if we use only 20% of the within Sulawesi volume as a measure of the amount of produce that could be marketed as fresh-cut product, at the peak season an estimated 13 MT would be need to be processed, packaged and cooled per day.

Packing the fresh-cut items into the recommended containers such as small plastic tubs or polyethylene bags increases the cost of packing and cooling and also increases the amount of time and refrigeration capacity required for cooling. For fresh intact produce that can be forced air pre-cooled from 30 C to 4 C in 6 hours or so, the time would be expected to double to 12 hours or more if the product were encased in plastic bags or tubs.

J. RECOMMENDED TOOLS AND EQUIPMENT

Purchases of several types of new tools, simple handling equipment and supplies will be required (numbers were calculated based upon expected volumes to be handled on a daily or weekly basis) and should include:

- Vented, stackable plastic crates for use as field containers and during pre-cooling (20 kg maximum size is suitable for potatoes and carrots, but smaller sizes (5 and 10 kg weight are needed for the other commodities)
- hand-dollies and hand pallet-jacks for moving stacks of plastic crates
- wooden pallets for making up pallet loads for the pre-cooling room
- shallow, vented fiberboard cartons for delicate produce such as green beans, tomatoes, chilis
- sizing rings, rulers and calipers

Several pieces of major equipment will need to be purchased or constructed on site:

Line #1 (potatoes, carrots)

- Washing tank
- Rinsing tank
- Drying table with fans
- Grading/packing tables
- Weighing stations

Line #2 (all other produce)

- Initial wash (for spring onions for remove soil from roots)
- Stainless steel trimming tables (to remove by hand the outer leaves of cabbages, cauliflower, onions, to cut the excess leafy tops/ excess roots from celery, spring onions; to remove any leaves, stems and plant debris from beans, chilis; to cut salak fruits from bunch on stalk, etc)

- Washing /brushing /drying equipment (for tomatoes and chili peppers only, optional as these tasks can also be done by hand using clean soft cloths)
- Waxing/ hot air dryer (for salak, tomatoes and chili peppers, optional)
- Sizing /grading tools and equipment
- Packing stations (large tables with space for 4 to 6 workers)
- Roller conveyor tables
- Weighing stations

III. ADDITIONAL PACKINGHOUSE DESIGN AND INFRASTRUCTURE CONSIDERATIONS

A. WATER SOURCE

The facility will require a water pump and water tower. Water quality should be tested to document potability.

B. ELECTRICITY SOURCE

Power supply should be assessed to ensure it is adequate to run all the equipment, lights, refrigeration systems and cold storage required to successfully operate the facility.

C. LIGHTING

Lighting fixtures will be required and they will need to be installed close to the workers to provide good light for sorting and grading activities.

D. COOLER DOOR OPENINGS

Care should be taken to utilize easy to access entrances to the pre-cooler(s) ad cold room(s). There should never be any rise in the flooring at the entrances (nothing to step over) and the doors should slide sideways to minimize the space required for access. All doorways, whenever they are open, should be covered with plastic strip curtains, to minimize the movement of heat into the cold areas, and to minimize the access of flying insects.

E. HAND JACKS FOR PALLETIZED CARTONS

Movement of pallet loads of produce into the pre-coolers, cold storage rooms and shipping vehicles can be made faster and easier for workers by using hand pallet jacks, available from many companies in the USA and worldwide. Some of these pallet jacks also include a scale, so pallets can be weighed and logged into the record books directly before shipping.

F. SANITATION AND FOOD SAFETY

General sanitation practices for wash water were described earlier in the report, and packingline cleaning and sanitation must be part of the daily activity for operating the packinghouse facility. Accepted food safety protocols require certain chemicals to be used or avoided (check local GAP and HACCP documents that are being used in Indonesia, or refer to EUREPGAP standards).

In addition to washing all the tables, floors and walls with an acceptable food grade cleanser or detergent, and rinsing everything down with clean, chlorinated water after each shift, it is important to implement the following recommendations if the budget will allow.

- Pavement should be laid on any dirt areas located outside the building, both to reduce dust and grime during produce deliveries and loading/unloading activities, as well as to provide a dust-free area for the cleaning and sanitizing of used plastic crates outside the structure.

- The floor inside the packinghouse building should be smooth, flat, and easy to clean surface, perhaps poured concrete or well sealed cement.
- An area for composting should be identified and set up nearby to handle all organic wastes generated by the facility.

G. DETERMINING MANPOWER REQUIREMENTS

The facility will require perhaps 40 personnel, including a general manager, packinghouse manager, receptionist, training supervisor, three or four skilled workers to manage the pre-cooling operations and the cold storage rooms, as well as a half dozen unskilled laborers to load or unload trucks, handle composting activities and general maintenance.

Each of the packing lines will use 8 to 10 workers per line, and any small scale semi-processing operations will require 3 or 4 workers for each process. Several workers will be also needed as drivers to transport produce from the cold rooms to the markets.

If the packingline workers can be cross trained to perform several different tasks on the various commodities and their specific packing lines, they can be used most efficiently as operations will vary based upon the quality and volume of the produce coming into the facility on a daily basis.

The facility will require a lot of management, from the hiring, training and supervision of workers, to planning and implementing packing, cooling, shipping, processing, composting and maintenance activities. Many of these skills are highly specialized, and so will require a management team of people with expertise in refrigeration and cold chain management. It may be possible to find a local packinghouse manager, but if possible, the general manager should be brought in from outside Sulawesi, and have international experience with vegetable packing, shipping and marketing. Local people could be selected by AMARTA to receive specialized training in the various tasks and skills required to operate and maintain the vegetable packing facility.

H. CALCULATING COSTS AND BENEFITS

- It was unclear whether a cold truck is available for making produce shipments from the farms to the facility and/or from the facility to the markets, but if such a vehicle is not already part of the planned program one or more trucks should be purchased or leased and the refrigerated transport costs taken into consideration when calculating per package handling costs.
- Expected costs should be calculated for operating each of the packing lines: the first is a simple manual handling line, using workers to clean, sort, grade and pack produce such as potatoes, cabbage, cauliflower, shallots, and carrots. The second line could be electric powered, using simple washing equipment, a waxing device with roller brushes, a hot air drier, etc to perform basic postharvest tasks for salak, tomatoes, chilis and the other vegetables that require cleaning and waxing before packing and pre-cooling.

Since each commodity will require a different mix of handling steps in order to maintain optimum market value, quality and shelf life, total handling costs should include manpower use estimates and power usage estimates. The comparative cost should be based upon the volume of each type of produce that can be expected to be packed each day (by season). It may become apparent that certain commodities do not merit extra handling (hand grading, costly packages or pre-cooling for example) if their market price is too low to provide a positive return on investment.

APPENDIX A: SOURCES OF SUPPLIES AND EQUIPMENT FOR PACKINGHOUSES

brusher/washer	Industrial Brush Corporation Northwest Int'l Equipment Co. Orchard Equipment and Supply Co. TEW Manufacturing Corp
chlorination and pH testing equipment/supplies	International Ripening Corp. American Machinery Cole-Parmer Instrument Company Hach Company Hanna Instruments, Inc. LaMotte Company Q A Supplies
cleaners	Brogdex Co. Orchard Equipment and Supply Co.
conveyors	Agri-Tech, Inc. Arrowhead Conveyor Corp., Dorner Manufacturing Corp Durand-Wayland McNichols Conveyor Co Michigan Orchard Supply Northwest Int'l Equipment Co. O/K Machinery Corp SJF Materials Handling Sorting Technology, Inc. Tew Manufacturing Corporation Wire Belt Company of America
fruit and vegetable waxes	Brogdex Co. Michigan Orchard Supply Orchard Equipment and Supply Co.
hand pallet jacks	Global Industrial Hyster Company Market Farm Implement Northern Tool and Equipment Toyota Material Handling USA
inspection roller tables	Market Farm Implement Orchard Equipment and Supply Co.
lifting/handling equipment fork lift attachment for tractor	 Orchard Equipment and Supply Co.
packing lines	Ag-Pak

	American Machinery TEW Manufacturing Co.
pH meters	Fisher International Ripening Corp.
plastic strip door curtains	Verilon Products Company
rotary tables	Market Farm Implement Michigan Orchard Supply Orchard Equipment and Supply Co. TEW Manufacturing Corp
refrigeration / cooling equipment	Grainger Export Krack Corp Barr Inc.
scales and weighing equipment	Doran Scales, Inc Global Industrial Northern Tool & Equipment Orchard Equipment and Supply Co. Q A Supplies Topline Digital Scales
sizers expanding rollers	 Northwest Int'l Equipment Co.
sizing rings	Orchard Equipment and Supply Co. International Ripening Corp.
stainless steel tables (adjustable height)	Equipment House KaTom Restaurant Supply
temperature/humidity tools	Q A Supplies
washers and waxers	Agri-Machinery Inc Agri-Tech, Inc Durand-Wayland, Inc. Industrial Brush Corporation Market Farm Implement Michigan Orchard Supply Orchard Equipment and Supply Co.

The following list is in alphabetical order by company name.

Ag-Pak Inc., Gasport, NY 14067. (716) 772-2651. TELEX 64-6865.

Agri-Machinery Inc., 3489 All American Blvd., Orlando, Florida 32810
Tele: 407.299.1592, FAX: 407.299.1489 E-Mail: info@agrimachinery.com

Agri-Tech Inc., P.O.Box 448, 100 Lakeview Drive, Woodstock, Virginia 22664.
(703) 459-2142, FAX (703) 459-4731.

American Machinery Corp., 2730 Eunice Ave, P.O. Box 3228, Orlando, FL 32802.
(407) 295-2581.

Arrowhead Conveyor Corp. 3255 Medalist Drive Oshkosh, Wisconsin 54902 Phone: 920-235-5562 Fax: 920-235-3638

Barr Inc., 1423 Planeview Drive Oshkosh, Wisconsin Phone: 920-231-1711 Fax: 920-231-1701

Brogdex Company, 1441 West Second Street, Pomona, California 91766. (909) 622-1021, FAX (909) 629-4564.

Chinook Packing Equipment, P.O.Box 15554, Boise, Idaho 83715. (208) 384-5418, FAX (208) 855-4155.

Clarkesville Machine Works, Inc., P O Box 378, Clarkesville, Arkansas 72830 (501) 754 7161 FAX (501) 754 8602

Cole-Parmer Instrument Company 625 East Bunker Court, Vernon Hills, Illinois 60061
Phone: 800-323-4340 Fax: 847-247-2929

Doran Scales, Inc., 1315 Paramount Parkway, Batavia, IL 60510 U.S.A.
Toll Free: 1-800-365-0084 Fax: 630-879-0073 Phone: 630-879-1200
sales@doranscales.com

Dorner Manufacturing Corp., 975 Cottonwood Avenue Hartland, Wisconsin 53029 Phone: 262-367-7600 Fax: 262-367-5827

Durand-Wayland, Inc., P.O. Box 1404, LaGrange, Georgia 30241. (706) 882-8161, FAX (706) 882-8161.

Equipment House (online business), sales@equipmenthouse.com
Phone: 678-360-7585 www.equipmenthouse.com

Global Industrial (online business) **(888) 978.7759** www.globalindustrial.com

Grainger Export, 2255 NW 89th Place Miami, Florida Phone: 305-591-2512 Fax: 305-592-9458

Hach Company, P.O. Box 389, Loveland, Colorado 80539 Phone: 970-669-3050

Hanna Instruments, Inc. 584 Park East Drive, Woonsocket, Rhode Island 02895 Phone: 401-765-7500 Fax: 401-765-7575

Hyster Company, 1400 Sullivan Drive Greenville, South Carolina 27834 Phone: 800-497-8371 Fax: 252-931-7877

Industrial Brush Corporation, P.O.Box 2608, Pomona, California 91769
Phone: (909) 591-9341, Fax: (909) 627-8916 Toll Free: (800) 228-6146
Email:ibcsales@industrial-brush.com

International Ripening Corporation, 1185 Pineridge Road, Norfolk, Va 23502, Phone (800) 472 7205

KaTom Restaurant Supply (online business) www.katom.com

Krack Corp., 401 South Rohlwing Road Addison, Illinois 60101 Phone: 630-629-7500 Fax: 630-629-0168

LaMotte Company 802 Washington Avenue Chestertown, Maryland 21620 Phone: 410-778-3100 Fax: 410-778-6394

Market Farm Implement, RD # 2, Box 206, Friedens, Pennsylvania 15541. (814) 443-1931, FAX (814) 445-2238.

McNichols Conveyor Co., 26211 Central Park Boulevard # 320 Southfield, Michigan 48076 Phone: 248-357-6077 Fax: 248-357-6078

Michigan Orchard Supply, 07078 73 1/2 Street, Southhaven, Michigan 49090. (616) 637-1111/ (800) 637-6426, FAX (616) 637-7419.

Northern Tool and Equipment, P O Box 1499, Burnsville, Minnesota 55337. (800) 533 5545, FAX (612) 894 0083 www.northern-online.com

Northwest International Equipment Co. Inc., P.O. Box 10932, Yakima, Washington 98909. (509) 575-1950, FAX (509) 452-3307.

O/K Machinery Corp., 73 Bartlett Street Marlborough, Massachusetts 01752 Phone: 508-303-8286 Fax: 508-303-8207

Orchard Equipment and Supply Co. , P.O.Box 540, Route 116, Conway, Massachussetts 01341. Phone: (413) 369-4335 or (800) 634-5557, FAX (413) 369-4431.

Q A Supplies, 1185 Pineridge Road Norfolk, Virginia 23502 Phone: 757-855-3094 Fax: 757-855-4155

Ramsay Welding and Machine Inc., 478 Brunken, Salinas, California 93901. (408) 422-6429, FAX (408) 422-9254.

N.H. Savage Equipment Inc., 400 Industrial Road, Madill, Oklahoma 73446. (405) 795-3394, FAX (405) 795-2448.

Semco Manufacturing Company, P O Box H, 705 E. Bus. Hwy. 83, Pharr, Texas 78577. (512) 787 4203; FAX (512) 781-0620

SJF Materials Handling, www.SJF.com, 211 Baker Ave W. Box 70 - Winsted, Minnesota, 55395 (800) 598 5532

Sorting Technology Inc., P.O. Box 479, American Falls, Idaho 83211. (208) 226-2727, FAX (208) 226-2750.

Tew Manufacturing Corporation, 470 Whitney Road West Penfield, New York 14526 Phone: 585-586-6120 Fax: 585-586-6083

Thomas E. Moore Inc., P.O.Box 794, Dover, Delaware 19903. (302) 653-2000, FAX (302) 653-3476.

Topline Digital Scales, 17587 Glasgow Ave. #2, Lakeville, MN 55044 USA
(800) 290-5071 CustService@ToplineDigitalScales.com

Toyota Material Handling USA, Inc. 1 Park Plaza, Suite 1000 Irvine, California 92623
Phone: 949-474-1135 Fax: 949-223-8000

Verilon Products Company, 452 Diens Drive Wheeling, Illinois 60090 Phone: 847-541-1920
Fax: 847-541-4525

Wire Belt Company of America, 154 Harvey Road Londonderry, New Hampshire 03053
Phone: 603-922-2637 Fax: 603-644-3600

APPENDIX B: POSTHARVEST FACTS FOR SELECTED PRODUCE

Vegetable Postharvest Facts for AMARTA
Source: USDA Handbook 66 (in press 2007)

Beans (green beans or string beans)

Physiological Disorders: Chilling Sensitivity. Snap and Pod beans are chilling sensitive, and visual symptoms will depend on the storage temperature. At temperatures below 5 °C (41 °F), the typical symptom of chilling injury is a general opaque discoloration of the entire bean. A less common symptom is pitting on the surface and increased water loss. At temperatures of 5 to 7.5 °C (41 to 46 °F), the most common symptom of chilling injury is the appearance of discrete rusty brown spots. These lesions are very susceptible to attack by common fungal pathogens. Beans can be held about 2 days at 1 °C (34 °F), 4 days at 2.5 °C (37 °F), and 6 to 10 days at 5 °C (41 °F) before chilling symptoms appear. No discoloration occurs on beans stored at 10 °C (50 °F), but undesirable seed development, water loss, and yellowing will occur at this storage temperature.

Postharvest Pathology: Various decay organisms may attack fresh pod beans as a result of chilling injury, surface moisture, or mechanical damage. Common decay causing fungi are those causing "nesting decays" (cottony leak caused by *Pythium* spp., *Rhizopus* spp), gray mold (*Botrytis cinerea*), and watery soft rot (*Sclerotinia* species). Watersoaked spots may be due to lesions caused by bacterial infections (*Pseudomonas* spp., *Xanthomonas* spp.).

Quarantine Issues: None.

Suitability as Fresh-cut Product: For foodservice, beans are snipped to remove stem and tails. Browning of the cut ends can be a problem, and high CO_2 atmospheres help retard discoloration.

Special Considerations: Extra careful and expedited postharvest handling are required for highly perishable very fine French beans or Haricot Verts to avoid physical damage and dehydration.

Bok Choy

Physiological Disorders and Postharvest Pathology: Leaf yellowing is a sign that senescence has occurred during extended storage, or under higher than optimal storage temperatures. Storing bok choy at 0 to 5 °C (32 to 41 °F) will mitigate this problem.

Quarantine Issues: None.

Suitability as Fresh-cut Product: No current potential.

Cabbage

Physiological Disorders: Some physiological storage disorders are clearly frost-induced, eg., black blotching, black spot, epidermal detachment, frost blemishing and redheart. Storage disorders can also be caused by dormancy, ethylene and head maturity.

Postharvest Pathology: The major cause of postharvest decay in cabbages is the gray mold fungus (*Botrytis cinerea*). Gray mold can be minimized by using less susceptible cultivars, using preharvest fungicides, practicing strict hygiene, avoiding mechanical or frost damage, rapid cooling to 0 °C (32

°F) and using CA storage. Another fungus, Alternaria rot, a.k.a. dark, black or gray leaf spot (*Alternaria* spp.), infects a wide range of cruciferous vegetables and can cause significant storage losses. Since this disease is commonly transmitted through infected seed, it can be minimized by using disease-free seed, rotation with non-cruciferous crops, preharvest fungicides, destruction of diseased material before storage and rapid cooling to 0 °C (32 °F). There are other fungi (eg., ring spot), bacteria (eg., bacterial rots and watery soft rot), and a virus (tobacco mosaic virus) that can cause significant losses.

Quarantine Issues: None

Suitability as Fresh-cut Product: Shredded cabbage is suitable as a fresh-cut product, packaged in air or MAP.

Carrots

Physiological Disorders: Bruising, shatter-cracks, longitudinal cracking, and tip-breakage are signs of excessively rough handling. Nantes-type carrots are particularly susceptible to mechanical damage. The severity of shatter-cracking is partially related to varietal background. Wilting, shriveling, and rubberiness are signs of moisture loss. Sprouting may occur on topped carrots if the storage temperature is too high. Bitterness can develop in storage due to the accumulation of isocoumarin, caused by disease or exposure to ethylene. Harsh flavor may be caused by the high terpenoid content, generally from pre-harvest water stress. Surface browning or oxidative discoloration often develops during storage, especially on carrots harvested immature.

Postharvest Pathology: The most prominent storage decays are bacteria soft rot (induced by *Pectobacterium carotovora* or *Pseudomonas marginalis*), gray mold rot (*Botrytis cinerea*), Rhizopus soft rot (*Rhizopus spp*.), watery soft rot (*Sclerotinia sclerotiorum*), and sour rot (*Geotrichum candidum*). Ozone is a fungistatic against *Botrytis* and *Sclerotinia*, but tissue damage and color loss occur after treatment. Good sanitation during packing and storing 0 °C (32 °F) are most important to minimize postharvest diseases.

Quarantine Issues: None

Suitability as Fresh-cut Product: A significant portion of fresh carrot production is used to produce fresh-cut products such as “baby carrots,” carrot coins, shreds, and sticks. Carrots directed or consigned to fresh-cut processing are typically harvested at an immature stage for optimal texture and taste. Fresh-cut carrots typically have a shelf-life of 3 to 4 weeks at 0 °C (32 °F) and 2 to 3 weeks at 3 to 5 ºC (37 to 41 °F). “White blush” has remained a problem for processors and shippers of fresh-cut carrots. The superficial whiteness is caused by dehydration of the cut surface. Low storage temperature and the presence of residual surface moisture significantly delays development of this disorder. Using sharp knives is important to reduce tissue damage and extend shelf-life.

Cauliflower

Physiological Disorders: Black speck is a disorder where 0.5 to 4 mm (0.02 to 0.16 in) diameter necrotic lesions appear on the surface of branches or flower stalks in the interior of the curds. This disorder is more prevalent on certain cultivars and is most severe in cauliflower produced under periods of warm weather and rapid growth. Boron deficiency can result in brownish discoloration of the curd and pith of the stems and may result in hollow stems. In addition, blisters and cracks may form on the midribs of leaves and curds may taste bitter. Riciness has been described as loose curds with floral parts protruding and can be induced when plants are exposed to > 20 °C (68 °F) prior to curd initiation and to 7 °C (45 °F) thereafter. Over-maturity and storage at elevated temperatures encourages its development, while it can be reduced by timely harvest and storage at 0 °C (32 °F).

Heads are susceptible to freezing injury, which appears as water-soaked and grayish curds, if held < 0.8 °C (30.6 °F).

Postharvest Pathology: The major causes of postharvest decay are bacterial soft rot caused by *Erwinia* and *Pseudomonas* spp., and brown rot caused by *Alternaria* spp.. Storing only good quality, disease-free heads and maintaining good temperature control can best control these decay organisms.

Quarantine Issues: None.

Suitability as Fresh-cut Product: Commonly converted to fresh-cut floret products.

Special Considerations: Growing conditions can strongly influence quality of fresh cauliflower. Heads must be protected from the sun, normally by tying the leaves, during development to prevent yellowing and strong flavor development in the curd. Only high quality heads should be stored or shipped long distances. Heads must be handled gently to avoid bruising which results in rapid browning and decay.

Celery

Physiological Disorders: Pithiness is a major source of quality loss and decreased shelf-life in celery. It is characterized by the appearance of whitish regions and air spaces within the tissues and reduced tissue density, and is caused by the breakdown of the internal pith parenchyma tissues of the petiole to produce aerenchyma. Pithiness may be induced by pre-harvest factors, including cold stress, water stress, pre-bolting (seed stalk induction), and root infection. Storage temperature has a major impact on development of pithiness after pre-harvest induction. Progressive development of pithiness is delayed by storage at 0 °C (32 °F).

Blackheart is a physiological disorder caused by cell death resulting from calcium deficiency, and pre-harvest water stress. Internal leaves develop brown discoloration, which eventually becomes deep black.

Brown check is a disorder related to boron deficiency. It appears as cracks on the inner petiole surface and is also refereed to as crack stem. The exposed tissues become brown and are susceptible to pathogen infection and decay.

Crushing or cracking are signs of mechanical damage, and may lead to rapid browning and decay. Harvesting, packing and handling should be done with great care to prevent damage to the highly sensitive turgid petioles.

Freezing injury starts at temperatures below -0.5 °C (31.1 °F). Mild freezing causes depressions in the tissues that subsequently turn brown. Severely frozen tissues develop wilted and water soaked appearance on thawing.

Postharvest Pathology: The most prominent storage decay is bacteria soft rot (primarily caused by *Pectobacterium or Pseudomonas*), gray mold (*Botrytis cinerea*), and watery soft rot (*Sclerotinia* spp.). Keeping storage temperature near 0 °C (32 °F) is important to minimize losses due to postharvest decay. Controlled atmospheres (1.5% O_2+ 7.5% CO_2) have been shown to suppress the growth of *Sclerotinia* and watery soft rot. However, careful maintenance of atmospheric composition is required as celery is sensitive to low O_2 and high CO_2 injury.

Quarantine Issues: None. However, export loads of celery may be fumigated at entry ports if common insects (aphids, thrips) are found.

Suitability as Fresh-cut Product: The majority of fresh-cut celery is in the form of celery sticks (cut petioles). Fresh-cut celery can be packed alone or in combination with other vegetables, such as carrots and broccoli. The shelf-life of fresh-cut celery is typically 12 to 14 days at 0 to 5 °C (32 to 41 °F). Discoloration of vascular tissue, splitting of the cut ends, and bacteria decay are major problems limiting shelf-life of fresh-cut celery.

Chinese cabbage

Physiological Disorders: Brown midrib, a physiological disorder causing significant storage losses, is a symptom of chilling injury. Elevated levels of CO_2 can increase decay and the occurrence of offensive odors.

Postharvest Pathology: Leaf spots can be caused by *Alternaria* spp., bacterial soft rot (*Erwinia carotovora*). Black discoloration of leaf veins may be due to *Xanthomonas campestris*.

Quarantine Issues: None.

Suitability as Fresh-cut Product: Chinese cabbage is suitable as a fresh-cut product packaged in air or modified atmosphere packaging (MAP). MAP treatment is moderately effective in extending the storage-life of shredded Chinese cabbage and provides respiration rates at different temperatures, atmospheres and varying amounts of shredding. The shelf-life limiting factors are browning on cut surfaces and leaf surfaces, as well as appearance of black speck (gomasho). If 1% citrate is used as a dip, a commercially acceptable shelf-life of 21 days at 0 °C (32 °F) or 14 days at 5 °C (41 °F) can be achieved without MA.

Gourds

Physiological Disorders: Gourds should be handled with care; damage to longitudinal ribs leads to water loss and decay. Fruit are susceptible to dehydration and toughening of the peel.

Postharvest Pathology: No specific information.

Quarantine Issues: None known.

Suitability as Fresh-cut Product: No current potential.

Special Considerations: Care must be taken with selection of the correct immature stage; damage to the ribs must be carefully controlled as it leads to water loss and decay.

Peppers

Physiological Disorders:
Blossom end rot is a disorder characterized by a slightly discolored or dark sunken lesion at the blossom end of the fruit. It is caused by calcium deficiency during growth. Pepper speck is a disorder that appears as spot-like lesions that penetrate the fruit wall. The cause is unknown; some varieties are more susceptible. Peppers are sensitive to chilling injury when stored below 7 °C (45 °F). Symptoms include surface pitting, water-soaked areas, decay (especially Alternaria) and discoloration of the seed cavity. Symptoms can appear after a few days at 0 °C (32 °F) or a few weeks at 5 °C (34 °F). Sensitivity varies with cultivar; ripe or colored peppers are less chilling sensitive than green peppers.

Postharvest Pathology: The most common decay microorganisms are *Botrytis*, *Alternaria*, and soft rots of fungal and bacterial origin. *Botrytis* (grey mold) is a common organism on peppers. Field sanitation and prevention of wounds on the fruit help to reduce its incidence. *Botrytis* grows well at the recommended pepper storage temperatures. High CO_2 levels (> 10%) can control *Botrytis*, but damages peppers. Hot water dips at 53 to 55 °C (126 to 130 °F) for 4 min can effectively control botrytis rot without causing fruit injury. The presence of Alternaria black rot, especially on the stem end, is a symptom of chilling injury. The best control is to store them at 7 °C (45 °F). Bacterial soft rot is caused by several bacteria which attack damaged tissue. Soft rots can occur on washed or hydro-cooled peppers, where water sanitation was inadequate. Peppers are also affected by many of the disease, virus, insect, and nematode pests that affect tomato.

Quarantine Issues: None

Suitability as Fresh-cut Product: Before cutting, peppers should be stored at 7 to 10 °C (45 to 50 °F). After cutting, fresh-cut peppers should be held at 0 to 5 °C (32 to 41 °F). Pepper slices (red and green) can be stored for up 12 days at 5 °C (41 °F) using a CA of 3% O_2 + 10% CO_2.

Special Considerations. Mechanically-harvested peppers are usually unsuitable for fresh market because of extensive injuries incurred, but can be used for processing. Peppers must be handled with care to avoid mechanical damage that may cause discoloration and pathological problems. Before packaging, peppers can be washed with 300 ppm chlorine to reduce disease. Waxing with fungicides reduces water loss and disease.

After drying, chili peppers are packaged tightly into sacks holding ≥ 200 lb (91 kg) and are generally stored in non-refrigerated warehouses for up to 6 months. The temperature of the warehouse depends on their construction and the way they are managed, but mainly on ambient outdoor temperature. Insect infestation is a major storage problem. In Southern states, chili and other hot peppers are dried, packaged, and stored at 0 to 10 °C (32 to 50 °F). Storage at low temperature retards loss of red color and slows insect activity.

Moisture content of chili and other hot peppers during storage should be low (10 to 15%) to prevent mold growth. A RH of 60 to 70% is desirable. With a high moisture content, pods may be too pliable for grinding and may have to be re-dried. With lower moisture content (< 10%), pods may be so brittle they shatter during handling, causing loss and release of dust, which is irritating to the skin and respiratory system.

The use of polyethylene film liners within bags allows better storage and reduces dust. The liners ensure that the pods maintain constant moisture content during storage until the time of grinding. Thus, they permit successful storage or shipment under a wide RH range. Peppers can be stored 6 to 9 mo at 0 to 4 °C when packed in this manner.

Manufactures of hot pepper products hold part of their raw material in cold storage at 0 to 10 °C, but prefer to grind peppers immediately and store the dried product in air-tight containers.

Potatoes

Physiological Disorders: The most common and serious physiological disorders affecting potatoes include black spot, blackheart, freezing injury, greening, hollow heart, sugar end browning, and internal necrosis. Black spot results from a physical impact to the tuber; the stem end of the tuber is most sensitive. Following severe bruising or cutting, the affected tissue turns reddish, then blue becoming black in 24 to 72 h. Severity increases with time. Cultivars differ significantly in their susceptibility and symptom expression. Soil conditions can predispose tubers to blackspot; poor aeration is the most common cause. Proper fertilization (particularly potassium), water management, careful handling and high RH to maintain turgor are important in minimizing black spot. Use of compost and/or manure helps prevent blackspot.

Blackheart is a storage or transportation induced disorder caused by low O2. Typically, blackheart is induced at > 30 °C (86 °F), which increases respiration. If air exchange around tubers is sufficient, low O2 conditions develop in the interior of the tuber and the cells suffocate and turn black. Blackheart is rare in early-crop potatoes due to typical marketing practices.

Freezing at -1 °C (30 °F), whether induced in the field or in storage, typically results in a distinct demarcation between affected and unaffected tissue. Symptoms include a water-soaked appearance, glassiness, and tissue breakdown on thawing. Chilling injury can occur after a few weeks at 0 °C (32 °F) and result in a mahogany discoloration of internal tissue in some varieties. Much longer periods of storage are generally required for chilling injury to occur.

Greening may occur in part of a tuber exposed to light. Affected tubers are easily culled at grading and rarely proceed to marketing channels. Darkness is essential for long-term storage because greening can occur during storage or marketing. Exposure to bright light during postharvest handling, or longer periods (1 to 2 weeks) of low light, can result in development of chlorophyll (greening) and bitter, toxic glycoalkaloids, such as solanine. Solanine also forms in response to bruising, wounding (including fresh processing followed by storage), and during sprouting. Glycoalkaloids are heat stable and minimally degraded by cooking. Tubers in market displays should be replaced daily or more frequently to minimize greening.

Enlarged lenticels are a common disorder in early potatoes where excessive irrigation is often applied to maintain cooler soil temperatures in warm/hot climates. These lenticels are subject to pathological infection in the soil or during packing. Infections may remain innocuous, or if transportation conditions are not properly maintained, they can increase rapidly in severity. Tubers that appear sound at the packing shed can become unmarketable during transit.

Skinning is a common disorder in early-crop or "new" potatoes (harvested immature). Soil drying and vine death enhance skin set, and thus decrease skinning. Cultivars vary in ability to set-skin, in skin thickness, and thus in skinning susceptibility. "New" potatoes must be kept at a very high RH, near 100%, and must be handled with special care. Hollow heart, sugar end accumulation and internal necrosis are all production problems, related to irregular growth, inadequate water availability and/or widely fluctuating temperatures; these conditions do not change during harvest and postharvest handling.

Postharvest Pathology: Diseases are an important source of postharvest loss, particularly in combination with rough handling and poor temperature control. Three major bacterial diseases and a greater number of fungal pathogens are responsible for, occasionally, serious postharvest losses. The major bacterial and fungal pathogens that cause postharvest losses in transit, storage, and to the consumer are bacterial soft rot *(Erwinia carotovora subsp. carotovora and subsp. atroseptica), Ralstonia* (ex *Pseudomonas,* ex *Burkholderi) solanacearum,* late blight (*Phytophthora infestans)*, Fusarium dry rot (*Fusarium* spp.), pink rot (*Phytophthora* spp.), water rot (*Pythium* spp.) and silver scurf (*Helminthosporium solani*). Occasionally serious diseases of immature tubers include pink eye (*Pseudomonas fluorescens*) and grey mold (*Botrytis cinerea*).

In addition to careful sorting before placing tubers into storage, management of air, RH and temperature during storage and transit of potatoes with potential problems can be accomplished. Lower RH, shortened curing time, and lower temperatures can minimize spread of rot diseases.

Quarantine Issues: Export and import of potato tubers can involve numerous quarantine issues related to grade, diseases, and nematodes. Each country has its own phytosanitary requirements. Inspections and appropriate authorizations are required. Among the most common diseases and nematodes included in quarantine, or zero tolerance requirements are cyst nematode (*Globodera spp.*), viruses and viroids, brown rot (*Pseudomonas solanacearum*), ring rot *(Corynebacterium sepedonicum)* and powdery scab (*Spongospora subterranean).* Similarly, these diseases and nematodes are restricted on potato tubers to be imported. Currently, potato tubers may not be imported into the U.S. from any country except Canada.

Suitability as Fresh-cut Product: Potatoes are relatively new as a lightly-processed product. Fresh-cut potatoes are not marketed, but par-boiled whole tubers can be prepared and marketed in plastic trays with sealed plastic wrap with low O_2 transmission characteristics. Storage requirements for tubers to be processed in this manner have not been well defined.

Special Considerations: Potatoes may impart an "earthy" odor to apples and pears if held in storage with low air exchange. Potatoes may acquire an off-flavor from odor volatiles released by other produce items.

Tomato

Maturity Stage	**Internal Appearance**
M-1	Seeds immature (white) and can be cut when the tomato is sliced; no gel in the locule.
M-2	Seeds mature (tan); gel formation in at least two locules.
M-3	Seeds pushed aside when tomato sliced; all locules have gel; internal color is still green.
M-4	Appearance of red color in gel and pericarp tissue.

Ripeness stages are defined according to the following standards for red-fleshed tomatoes (USDA, 1991):

Ripeness Stage[1]	**External Color**
Green	fruit surface is completely green; the shade of green may vary from light to dark.
Breaker	there is a definite break in color from green to tannish-yellow, pink or red on not more than 10% of the surface.
Turning	> 10% but not more than 30% of the surface is not green; in the aggregate, shows a definite change from green to tannish-yellow, pink, red, or a combination thereof.
Pink	> 30%but not more than 60% of the surface is not green; in the aggregate, shows pink or red color.
Light red	> 60% of the surface is not green; in the aggregate, shows pinkish-red or red provided not > 90% of the surface is red color.
Red	more than 90% of the surface is not green; in the aggregate, shows red color.

[1]Tomato color standards USDA Visual Aid TM- L-1 consists of a chart containing twelve color photographs illustrating the color classification requirements and may be purchased from The John Henry Company, 5800 W. Grand River Avenue, P.O. Box 17099, Lansing, MI 48901-7099.

Chilling Sensitivity: Tomato fruit are chilling sensitive and the recommended storage temperature varies with the maturity stage. Mature-green fruit will ripen normally at 13 to 21 °C (55 to 70 °F). On the other hand, ripe tomato fruits can be stored at 10 °C (50 °F), without visible symptoms of chilling injury, although flavor and aroma was negatively affected. Visual symptoms of chilling injury include pitting, non-uniform ripening and storage decays (see "Postharvest Pathology" section).

Physiological Disorders: Blotchy ripening is a physiological disorder characterized by the randomized development of green or green-yellowish areas on the surface of red tomato fruit. Apparently, the development of this disorder is related to the availability of potassium and inorganic nitrogen in the soil system. Areas showing blotchy ripening have less organic acids, SSC, and starch.

Sunburn is associated with excessive exposure to the sunlight and the resultant elevated tissue temperature during fruit development, disrupting lycopene synthesis and resulting in the appearance of yellow areas in the affected tissues that remain during the ripening process.

Blossom-end rot is a physiological disorder involving a calcium deficiency that is either due to poor uptake or translocation into the fruit. Symptoms begin in the green fruit as a small discoloration at the blossom end that increases in size and becomes dry and dark-brown. Occurrence increases dramatically when calcium levels in the soil system drop below 0.08%. Eventually, secondary decay organisms colonize weakened tissues.

Graywall is noticeable as necrotic vascular tissue in the pericarp fruit wall. It begins developing at the green stage and has been associated with marginal growing conditions such as cool weather, low light levels, poor nutrition, saturated soils, tobacco mosaic virus and bacteria; however, the cause is still undetermined. Graywall can be a serious disorder in both field and greenhouse production systems.

Irregular ripening is characterized by the appearance of non-uniform ripening and white internal tissue. It has been associated with the feeding of sweetpotato whitefly (*Bemisia argentifolii*) on tomato fruit.

Internal bruising is recognized by the appearance of yellow to green locular gel in ripe tomatoes. It is caused by an impairment of normal ripening of the locular gel following a physical impact at the green or breaker stage of ripeness. Fruit with internal bruising show significant reductions in Vitamin C content, TA, consistency and total carotenoids. Besides altering quality attributes, internal bruising also affects tomato fruit flavor. Breaker-stage tomatoes are more sensitive to internal bruising than those handled at the green stage.

Postharvest Pathology: Tomatoes are susceptible to numerous fruit decays, from the field through postharvest handling. Postharvest decays often develop in wounds, bruised tissue and during fruit softening. Sound tomatoes can be inoculated by plant pathogens via cross-contamination from diseased fruits, dirty harvest containers and from poorly sanitized water handling systems and packing line components. Populations of decay pathogens can be adequately controlled through a regular sanitation program in the field and during handling, packing and ripening/storage operations.

Bacterial decays include soft rots (*Bacillus* spp., *Erwinia carotovora* ssp., *Pseudomonas* spp., and *Xanthomonas campestris)*; lactic acid decay (bacterial sour rot) (*Lactobacillus* spp. and *Leuconostoc mesenteroides*).

Fungal decays include alternaria rot (black rot) (*Alternaria alternata*); Fusarium rot (*Fusarium* spp.); Gray Mold rot (*Botrytis cinerea*); Mucor rot (*Mucor mucedo*); Phoma rot (*Phoma* ssp.); Phomopsis rot (*Diaporthe* ssp.); Phytophthora rot (Buckeye rot) (*Phytophthora* spp.); Pleospora rot (*Pleospora herbarum; Stemphylium botryosum,*imp. stage); Rhizopus rot (*Rhizopus stolonifer, R. oryzae*); Ring rot (*Myrothecium roridum*); Sclerotium rot (*Sclerotium rolfsii*); Sour rot (*Geotrichum candidum*); Target spot (*Corynespora cassiicola*); Watery soft rot (*Sclerotinia minor, S. sclerotiorum*). Tomato spotted wilt virus induces a mottled coloration at red stage.

Quarantine Issues: Tomato fruit are a host for fruit flies, and are subject to inspection in quarantined areas. Methyl bromide has been employed for a wide range of fruits and vegetables. However, it is being phased out. Tomatoes have a phytotoxic response, characterized by delayed ripening and reduced sensitivity to exposure to ethylene. Vapor heat and hot water treatments are effective alternatives.

Suitability as Fresh-cut Product: Despite efforts to commercialize fresh-cut tomatoes, such products are still only available in limited quantities to the food service industry, particularly fast-food restaurants and catering services. After processing, loss of the gel-like locule tissue, desiccation, water-soaking and the development of decay are the principle constraints challenging the worldwide fresh-cut industry. Crossing commercial varieties with mutants with delayed softening, and slicing less ripe tomatoes, eg., breaker stage, for subsequent application of ethylene are strategies being researched in different parts of the world to obtain a fresh-cut tomato with sufficient postharvest-life to be readily commercialized. Mature-green, sliced tomatoes ripened normally at 20 °C (68 °F). Sliced, red tomatoes maintained good quality for 14 days when stored in MAP at 5 °C.

Special Considerations: Ethylene used to ripen tomatoes can be catalytically generated from ethanol using commercially available units, or supplied from compressed air cylinders. Because air mixtures of 3 to 32% ethylene are explosive, ethylene for ripening rooms is supplied from a compressed cylinder containing a < 3% ethylene in N_2 mixture. A metered flow of ethylene from either a catalytic unit or compressed cylinder is used to produce a diluted, active concentration of ethylene in the ripening room.