CHEMONICS INTERNATIONAL INC.

Postharvest Handling and Packinghouse Analysis of Fresh Produce and Recommendations for Improving Packing Line Design

Dominican Republic Competitiveness and Policy Reform
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Executive Summary

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Executive Summary

This report provides an analysis of the postharvest handling practices and packinghouse design for Asian vegetables and other fresh produce items from the La Vega Fruit and Vegetable Cluster. It is intended to offer guidance to the producers/exporters on ways to improve individual packinghouse operations in their efforts to sustain and expand export market volume. A number of simple and practical improvements are needed in individual packinghouse operations to improve efficiency of product flow and postharvest quality.

Inadequacies were identified in five principal areas of the postharvest care and handling of Asian vegetables. These inadequacies negatively impact product market quality and include: 1) rough harvesting and handling practices; 2) inefficient flow of product through the packinghouse during the various steps in market preparation; 3) inadequate product cooling and postharvest temperature management; 4) lack of postharvest humidity control; and 5) poor postharvest sanitation practices.

Recommendations for improvement include:

- more vigilant workforce supervision and attention to the details of using proper harvesting and postharvest handling practices
- careful monitoring of packinghouse operations, particularly water sanitation and product handling practices during sorting/grading/packing
- the addition of conveyors for product unloading, movement through the packinghouse, and loading
- use of electronic balances for more efficient and accurate carton weighing
- forced-air cooling for more rapid removal of product field heat
- installation of additional refrigeration capacity to the storage rooms
- installation of humidifiers in the storage areas to increase atmospheric moisture content to 90-95% relative humidity.

Adoption of these recommended changes will become increasingly necessary to maximize potential market life and satisfy future product quality demands and food safety requirements of the North American and European importers, particularly the larger supermarket chains. Those exporters capable of providing consistent supplies of safe, high quality product will have a significant marketing advantage.

The suggested design of a generic packinghouse is included along with illustrations on ways to maximize efficiency of product flow from receiving, through the steps in market preparation, storage, and finally to loading of the transit vehicle bound for the port of departure. Specific recommendations are also provided on how to improve product handling, postharvest care, and packinghouse operations. For further support of the Asian vegetable export industry, it is recommended to provide technical assistance, demonstrations, and training materials to growers,

exporters, and Ministry of Agriculture extension personnel on appropriate postharvest care for specific crops and packinghouse operation practices. In addition, trials with new and potentially effective postharvest technologies (i.e. modified atmosphere packaging, waxes, surface coatings) to improve product market life and quality should be conducted.

SECTION II

Acknowledgements

SECTION II

Acknowledgements

I would like to thank Marsha Krigsvold, Agribusiness Specialist with the Dominican Republic Program for Policy Reform and Competitiveness, for her total cooperation, scheduling of packinghouse visits, and logistical support during my stay in the Dominican Republic. I also would like to thank the producers and exporters of the La Vega Fruit and Vegetable Cluster for their hospitality and openness during the site visits. Appreciation is extended to Rafael Villar, Nicolas Rosario, Kensei Oba, Rafael Cosme, Victor Rodríguez, and Pedro Restituyo. Gratitude is also extended to Juan Jose Aracena for his insight and presence which made the packinghouse visits flow smoothly.

SECTION III

Background

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Background

Since 1998, USAID/Dominican Republic (DR) has supported the implementation of a program to improve the competitiveness of the DR in the global economy. The program has focused on promoting a policy environment in trade and agriculture that will lead to the creation of more jobs in key economic sectors and to change the mindsets of the public and private sectors around initiatives to increase word competitiveness. The objective of the current project is to support the competitiveness activities already underway with the micro, small, medium, and large Dominican enterprise sectors, and the Secretariat of Industry and Commerce's National Competitiveness Council. One beneficiary of the private sector initiative of the project is the La Vega Fruit and Vegetable Cluster, which produces, packs, and exports approximately $45 million annually to the U.S., Canada, and Europe. The packing facilities for the majority of packer/shippers are small, poorly designed open or partially open sheds with difficult or no direct access for refrigerated trucks or containers. The packing lines and postharvest treatment areas inside the packinghouses are poorly laid out. Cold rooms, cold water treatment lines, and box storage areas may be non-existent, inadequate, or badly located within the facility. As a result of the deficiencies in packinghouse layout and inadequate infrastructure, there are problems with occasional detentions of shipments in Miami or New York due to the discovery of "hitchhiker" insects in refrigerated containers and inadequate cooling of some fruits and vegetables. The lack of maintenance of an unbroken cold chain from product receiving to export shipping may result in inconsistent product arrival quality and reduced shelf life.

The La Vega Cluster has identified certification for Good Manufacturing Practices (GMPs) and EUREPGAP standards as an important strategic initiative for more competitive marketing of their products. In order to meet this goal, many of the smaller and medium-sized packing/exporting operations will have to make significant investments in their facilities to meet the HACCP requirements for hygienic postharvest handling of the products. Additionally, the Cluster's packer/exporter component identified as an important strategic initiative the reduction in product spoilage and lowering of costs by improving postharvest handling practices.

SECTION IV

Approach / Specific Tasks/Responsibilities

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The specialist will meet the La Vega Fruit and Vegetable packer/exporter community and visit representative packinghouse facilities. Diagnosis of the packinghouse facilities, packing activities, and cold water treatment for the control of thrips will be made in order to assist the exporters in making appropriate improvements to their facilities and increase export product quality for Asian vegetables.

The specialist will present a seminar on the basic design of a fruit and vegetable packinghouse and postharvest care. It will be given to a broad group of individuals representing various sectors of the export community.

The specialist will provide a written report of the findings of packinghouse visits and make appropriate suggestions or recommendations to improve the facilities. This will include a packinghouse design for a small to medium-sized Asian vegetable packing operation and a Power Point presentation to support and explain the design and appropriate postharvest handling practices.

SECTION V

Purpose of Assignment

SECTION V

Purpose of Assignment

The purposes of the assignment are to: 1) diagnose and suggest design changes in the infrastructural layout and packing line design of the packinghouses of participating packers; and 2) design a general packinghouse and packing line for small to medium-sized export operations.

SECTION VI

Assessment of Harvesting, Postharvest Care, and Packinghouse Operations

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Assessment of Harvesting, Postharvest Care, and Packinghouse Operations

Asian vegetables are well adapted to the La Vega area and high yields of excellent quality product are obtained by a number of growers. It is imperative to use proper harvesting and postharvest handling practices that maintain product quality capable of meeting the high standards demanded in the export market. Due to the perishable nature of fresh vegetables, it is important to quickly transport the harvested vegetables to the packinghouse and have a smooth and efficient flow of product inside packinghouse. In addition, the handling practices used inside the packinghouse while preparing the product for export must preserve the quality and maximize the potential market life. Observations made of the harvesting and postharvest practices at multiple locations in the La Vega area revealed a number of less than optimal handling practices. The potential areas for improvement and suggested interventions are discussed below.

A. Harvesting Practices

The manner in which the fresh vegetables are picked directly impacts product quality and market life. The delicate nature of the vegetable's skin and internal flesh should always be kept in mind while harvesting and handling the product. Wounding, bruising, and physical injury imparted to the product from rough and abusive harvesting practices will result in significant product quality loss and an increase in postharvest decay. Damaged areas serve as entrance points to bacterial and fungal pathogens that are ever present in the surrounding environment.

A range in product care was observed among field workers during harvesting. However, the majority of pickers used excessively rough harvesting practices and often threw the product into the field container without regard of bruising or physical damage. Gloves were not worn by the pickers to protect the product against skinning and potential fingernail damage. Close observation of the product surface, particularly the more delicate Asian vegetables, revealed

significant skinning and fingernail damage. Educating the workers on appropriate harvesting practices is recommended along with closer field supervision in order to minimize product injury. Possibly incentives of additional salary or other bonuses can be offered to the pickers in order minimize harvest injury.

It is a well established fact that the highest amounts of bruise damage during picking occurs when product pulp temperatures are at their highest. The worst possible scenario for harvesting is to pick the product in the heat of the afternoon and handle it roughly. Ideally, harvesting should occur only during the cooler morning hours. It is also very important to keep the product as cool as possible after harvest, as high pulp temperatures result in accelerated rates of ripening and deterioration and reduced market life. In many instances the field containers with harvested product were left exposed to direct sunlight. This is not conducive to maintenance of product quality. The field containers should be put under shade to minimize product heating in the interval between harvest and transport to the packinghouse.

The smooth inner-surfaced plastic pails and rigid plastic field containers used for harvesting and transport are appropriate for Asian vegetables and should continue to be used. They are easily cleaned, strong and withstand stacking without collapse. The smooth inner surfaces help minimize surface abrasion of the harvested product. The plastic pails and field containers should be washed and cleaned on a daily basis to avoid the accumulation of dirt and debris. The skin of Asian vegetables is very delicate and sensitive to abrasion. Contact or rubbing of the product

against a rough surface of the field container will cause injury. Furthermore, allowing the accumulation of dirt on the bottom and sides of the field container is unsanitary and increases the potential risk of transmitting food-borne illness germs to the fresh product.

Pickers should not mix non-export market quality product with the higher quality exportable product. It is important to do this initial field selection/grading in order to reduce unnecessary product handling and reduce the workload of packinghouse personnel. Close supervision of the field workers during harvest is necessary to ensure only export market quality product is sent to the packinghouse. A pre-sorting field station can also be used to cull out damaged, defective, and diseased, items. This field station should be shaded and located in an easily accessible area.

B. Transport of Product to Packinghouse

Rough handling practices were observed during loading of the field containers on the transit vehicle and unloading at the packinghouse. Throwing of the field containers and excessive drop heights were commonly observed. The consequences of these undesirable practices included noticeable physical injury and bruise damage to the product. The likelihood of postharvest decay of the injured items is high. The process of loading the field containers onto the transit vehicle and unloading at the packinghouse needs closer supervision. All product handling personnel

need to be educated on the importance of handling fresh produce gently like eggs, instead of like hardware. The use of inclined rollers or conveyor belts will ease the burden of field vehicle unloading and minimize the amount of handling damage incurred to the product.

C. Packinghouse Water Sanitation

Proper sanitation practices must be followed whenever fresh produce is exposed to water. It is very important to provide the product with protection from postharvest decay organisms and against possible food-borne illness contamination. Inadequate water sanitation during the *Thrips palmii* insect disinfestation procedure is a potential source of microbial inoculum that may accentuate postharvest decay. Phytosanitary regulations in the U.S. and E.U. require certain Asian vegetables be totally free (zero-tolerance) of live *Thrips palmii.* The MIP division of the Dominican Republic Ministry of Agriculture has a set protocol exporters must follow. The specific Asian vegetables which must be treated include eggplant (berenjena), long beans (vainita), bitter melon (cundeamor), and long squash (musu). The protocol consists of a two-stage postharvest submergence treatment in a bath of ambient-temperature water with a crop oil/fatty acid-soap compound (i.e. Ecofrut, Safer, two others) for 15 minutes, followed by a 15 minute submergence treatment in cool water (i.e. ~ 4°C).

Inadequate sanitation of packinghouse wash water and thrips disinfestation tanks was common to all six sites visited. This included a lack in frequency in change of the water in the tanks, along with no monitoring of the chlorine concentration and pH of the water over time. Submergence of fresh produce in un-sanitized water contaminated with bacterial and fungal pathogens will significantly increase the likelihood of postharvest decay. This is especially true if the product is injured or wounded, which is common. Also, if partially decayed products are put in the wash tank with the marketable products, inoculation of the healthy products with microbial spores is likely, followed by eventual postharvest decay. It may be difficult to see the decay, as the item may be contaminated with dormant spores of micro-organisms waiting to germinate and begin the decay process.

Due to the time lag between infection and symptom development, La Vega exporters do not perceive the seriousness of exposing fresh produce to un-sanitized water. Decay symptoms that appear during product distribution or marketing in the export country result in price adjustments and less return to the exporter. In addition, those exporters who develop the reputation for having arrival quality and decay problems on their products run the serious long-term risk of losing their market to higher quality suppliers.

Proper sanitation of the wash water is accomplished by maintaining a free chlorine concentration of 150 ppm and pH of 6.5-6.8. Although the majority of exporters visited added chlorine bleach to the submergence tanks, it was done only once at the beginning of the initial treatment. There was no attempt to monitor the free chlorine concentration over time. None of the packinghouse operations had the equipment or knowledge on how to monitor chlorine concentration or measure pH of the water. The current washing and thrips disinfestation practice common to all packinghouses significantly increases the risk of product postharvest decay if the free chlorine concentration and pH are not frequently monitored and appropriately adjusted. Utilization of properly sanitized wash water containing the appropriate chlorine concentration and water pH will significantly reduce the spread of disease and reduce problems with postharvest decay.

Chlorine (bleach) is readily available in Dominican supermarkets as a 5.25% sodium hypochlorite formulation. The exact amount of chlorine to add to obtain a 150 ppm solution depends on the wash tank volume. Adding 2.4 pints of 5.25% sodium hypochlorite per 100 gallons of wash tank water will give a 150 ppm chlorine solution. (For smaller wash tanks, this is equivalent to adding 0.24 pints of 5.25% sodium hypochlorite per 10 gallons of water). Expressed in the metric system, this is equivalent to adding 3.0 liters of 5.25% sodium hypochlorite per 1000 liter wash tank water volume. (For smaller wash tanks, this is equivalent to adding 0.30 liters of 5.25% sodium hypochlorite per 100 liters of water).

The pH of the water must be maintained between 6.5 and 6.8 for maximum effectiveness of the chlorine solution. If the water pH is 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 easily be raised by adding a small amount of lye (NaOH). These additives are readily available in supermarkets. The exact amount of material to add to the wash water tank depends on the initial water pH and the volume of the tank. Use of the recommended chlorine dose and wash water pH will do an excellent job of sanitizing the surface of produce.

As more produce items are added to the wash water, the chlorine concentration will decrease. This is the result of soil particles, dirt, debris, and the produce itself lowering the chlorine concentration over time. Therefore, if the same wash water is being re-used for extended periods of time, vigilant monitoring of the free chlorine level in the water is advised. Checks should be made at least on an hourly basis. Simple test strips and colorant test kits are available for determining chlorine concentration. Several water testing and chemical supply companies in the U.S. sell these chlorine monitoring devices (Hach, LaMotte; see Appendix). 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 a direct an almost instantaneous reading of the water pH. Vendors of digital pH meters include Hach and Cole-Parmer; see Appendix). The water pH should also be checked at the same time as the chlorine is monitored.

Recommendations for future project activities include providing training and technical assistance to exporters and packinghouse personnel on proper sanitation practices, chlorine monitoring, and water pH measurement.

D. Facilitation of Product Movement

There is currently too much use of manual labor for moving the product through the packinghouse. Significant improvements in worker efficiency and product movement may be realized by using roller conveyors and/or revolving belts in the packinghouse operations**.**

Roller conveyors should be used in each of the following steps to facilitate product movement and reduce manual handling:

- unloading of product from the truck into the cleaning/washing area
- movement from the wash tanks to the drying area and grading/sorting tables
- movement of the packed and weighed cartons to the cooling/storage area
- loading of the export cartons from the refrigerated storage area onto the trucks or marine containers destined for the airport/seaport.

For maximum efficiency of product movement inside the packinghouse, conveyors should be used to replace manual lifting and carrying wherever feasible. The height of the conveyor should be set at a level accommodating to the workers, which is typically between 2 to 2.5 feet. Movable roller conveyors on wheels are recommended. This will allow for the use of the same conveyor for several of the different packinghouse processes. For example, once unloading is finished, the same conveyor can be used to move the product from the wash tank to the grading/sorting area. Likewise, the same conveyor used for unloading of the field containers may be used for loading of the packed cartons onto the transport vehicle destined to the port.

After packing and weighing the export cartons, they can either be moved individually on top of another roller conveyor to the cooling area, or put on a pallet which is moved by a hand jack to the cooler. Following cooling and/or temporary storage, the cartons can be moved by roller conveyor (or by hand jack, if palletized) from the refrigerated holding room and loaded directly into a refrigerated truck or marine container destined for the airport or seaport.

The processes of grading and sorting the product can be made considerably more efficient by the use of revolving conveyor belts to move the product to the workers. Currently, workers grade and sort the product directly from the field containers while either seated, or while standing alongside a receiving table. This requires a considerable amount of work and movement in obtaining the product from the field container and moving the finished packed carton to nearby holding. In addition, sitting in a confined position and constantly having to get up and sit down for container/carton movement will soon result in worker fatigue and loss of grading efficiency.

Utilization of conveyor belts to move the product to graders standing on either side of the moving belt is significantly more efficient and less stressful on the packinghouse personnel. Semi-automating the grading/sorting process by the use of conveyor belts is highly recommended. The belts will be universally applicable for use with all the different Asian vegetables.

E. Packing/Weighing

The wax-impregnated corrugated cartons currently being used for exporting the majority of Asian vegetables from the Dominican Republic are strong, well-ventilated and adequate for long distance shipment. Use of non-waxed or structurally weak corrugated cartons should be avoided, as exposure to high humidity during transport and distribution will result in carton collapse and damage to the product inside the carton.

NO overfilling or overstuffing of product inside the export carton was observed for many commodities. This results in considerable product compression injury and damage, since the bulging product inside the overfilled carton supports the weight of the carton stacked above it, rather than the walls of the carton itself. When stacked, the container itself should bear the weight load and not the contents inside.

The packed cartons are currently weighed using older movable-weight style scales. This is a slow process and lack of weight precision may result in unnecessary product being added to the

carton, or worse yet, insufficient product. It is highly recommended to replace the old style weighing scales with modern digital readout display scales. Over the long run, this will save money by being able to weigh the carton with greater accuracy and it will also speed up the weighing process.

F. Cooling

Proper temperature management is the single-most important factor influencing postharvest life and market quality of all horticultural crops. The rate of product deterioration is directly correlated to the postharvest holding temperature.

Most of Asian vegetables grown for export have a high product respiration rate and limited postharvest life. At ambient temperatures the processes of ripening, softening, and decay continue unabated and at a high rate. The result is less than optimal product quality upon arrival at the destination market, and in many cases rejected or downgraded loads. Consequently, considerable market share is lost and significant economic losses may be suffered by the exporter. Importers demand and expect a consistent supply of high quality product, much better than found in most domestic markets.

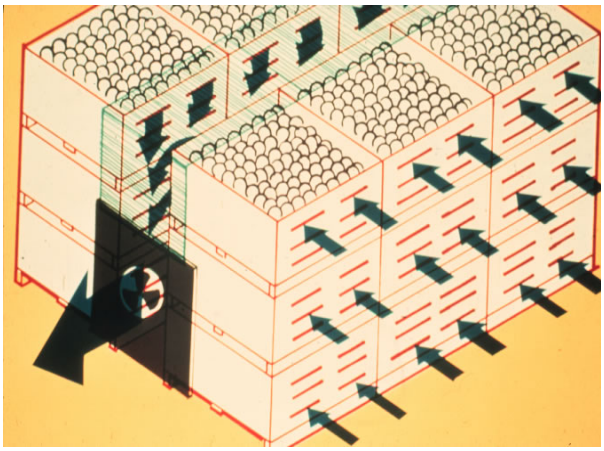
Inadequate cooling or holding Asian vegetables at a non-refrigerated ambient temperature (~ 24°C or 75°F in the shade) in the La Vega area is very undesirable. It is imperative to cool the products to their optimal storage temperature as soon as possible after harvest, ideally within one hour or less after picking. A general rule of thumb is that a product loses 10 hours of potential market life for every hour it remains at field temperature (i.e. > 75°F) after harvest. This is particularly relevant to the highly perishable products like vainita, leafy vegetables, and items harvested at a very immature stage.

The refrigerated storage rooms currently used by most exporters are not designed for rapid removal of product field heat. They are all basically polyurethane insulated room coolers with wall or ceiling mounted evaporators and fans.

Room cooling is a slow and inefficient method of removing product field heat. A much faster and more effective cooling method is to use forced air. The rate of cooling may be up to 5 times faster using forced air versus room cooling. The cooling rate should be sufficiently quick to remove the product's field heat to near the optimal storage temperature within 1-2 hours after harvest.

Asian vegetable exporters should be using forced-air cooling rather than room cooling to remove a commodities field heat and lower the pulp temperature to near the product's ideal storage temperature. Forced-air cooling is relatively simple and easy to do inside an existing refrigerated storage area. It basically involves purchasing a fan with enough capacity to pull air through 2 parallel rows of closely stacked or palletized cartons covered with a canvas or tarpaulin and separated by the width of the fan. The product is cooled rapidly by the difference in air pressure on opposite faces of stacks of vented containers (pallet boxes, corrugated cartons, flats, etc.). Fan(s) create the pressure difference, which is called static-pressure difference or pressure drop. This pressure difference forces air through the containers and product, removing produce field

and respiration heat. The product is most efficiently cooled when the cooling air flows around the individual fruits or vegetables in the containers, rather than by flowing around the outside of the containers, as is the case with room cooling. Forced-air coolers can be made more efficient by sealing air-leak areas to force additional air through products, improving carton stacking configurations or orientation, modifying pallet-tunnel length and width, and proper temperature monitoring.



Forced-air cooling will require the installation of additional refrigeration capacity (i.e. additional evaporator units and BTU's) in most of the existing packinghouses to meet peak product volume demands. The majority of existing room coolers are quite small and do not have the refrigeration capacity to rapidly remove product field heat. The amount of refrigeration capacity required is based on several factors, including initial product temperature, optimal storage temperature, rate of cooling, amount of product, and type of product. The following formula is used to determine the amount of refrigeration capacity needed to cool a product:

BTU's (of heat removed) = **Product Weight** (lb.) x **Specific Heat** (of product) x **Temperature Difference** (between product pulp temperature and final desired storage temperature in °Farenheit)

Refrigeration capacity is expressed in either BTU's or tons of refrigeration. One ton of refrigeration equals 12,000 BTU/hr. This is equivalent to about 3.5 kilowatts of refrigeration. Tonnage of mechanical refrigeration capacity (or BTU's) needed for cooling and refrigerated storage rooms can be estimated by using the above formula.

An additional 25% should be added to calculated amount from the equation to allow for removal of heat from product respiration, carton and worker heat, and leakage of cool air from opening the cooler entrance door. The total amount (calculated value from the equation, plus 25%) is the number of tons of refrigeration capacity required per hour. For example, to cool 4000 lb. of eggplant to 50°F from a pulp temperature of 80°F:

4000 (lbs product) x 0.94 (specific heat) x 30 (80 F to 50 F) = 112,800. 12,000 = 9.4 tons of refrigeration;

Add 25% to 9.4 tons = 11.75 tons of refrigeration capacity (41.13 kW)

The walls and ceiling of the cooling room should be insulated with polyurethane (2-inches thick) to preserve the cool temperature inside and reduce the refrigeration load. In some of the packinghouses, it was observed that areas of the wall and ceiling were void of sufficient insulation material. Spraying on addition polyurethane foam in these areas is recommended.

G. Refrigerated Storage

After cooling, it is important to hold the product at its optimal storage temperature prior to transport to the seaport or airport for export. The optimal postharvest holding temperature for the vast majority of Asian vegetables exported from the Dominican Republic is between 45-50°F (7-10°C). Storage of the fresh produce items at ambient temperatures (typically between 75°-85°F) results in an accelerated rate of ripening, softening, and postharvest decay. Inadequate refrigerated storage temperature control was a common problem observed in all the packinghouse sites visited. In most cases, the products were being held at higher than optimal postharvest temperatures for maximizing shelf-life.

Exporters should know the optimal storage temperature and postharvest care conditions for each of their products in order to maximize potential market life. In some cases this was not known and product market life was being compromised. The table below lists the optimal storage temperature, relative humidity, and other characteristics for some of the Asian vegetables exported from the La Vega area.

Storage Recommendations and Properties of Asian Vegetables					
Product	Storage Temp. °F	Water Content %	Relative Humidity %	Specific Heat	Respiration Rate (at storage temperature) BTU/lb/day
Vainita	40-45	89	90-95	0.91	3.76-3.83
Bitter Melon	45-50	96	90-95	0.97	2.53-3.20
Eggplant	45-50	93	90-95	0.94	n/a
Hot Peppers	40-45	95	90-95	0.94	1.60
Long Squash	45-50	94	90-95	0.95	n/a

It is very important to maintain the cold chain during transport of the product to market. This includes in-land transport within the Dominican Republic and during transit via sea or air to the final destination market. Refrigerated trucks set at the proper temperature for the product being transported should be used for in-land transport. Refrigerated sea containers may also be positioned at the packinghouse for product loading, followed by over-the-road transport to the departure port.

H. Relative Humidity Control

In addition to postharvest temperature management, relative humidity control is the next most important factor determining product market life and quality. Asian vegetables are high in moisture content and highly susceptible to wilting and shriveling after harvest. Maintenance of a high relative humidity during storage is extremely important for preserving the market quality and texture of fresh vegetables. Products such as vainita, eggplant, and leafy crops soon wilt and become flaccid under low humidity conditions. This significantly reduces quality and market value.

A high storage atmosphere relative humidity is necessary to maximize potential market life. In order to minimize product wilting and moisture loss, it is recommended to hold Asian vegetables at 90-95% relative humidity. This will require supplemental humidification systems and a humidistat in the storage area to regulate the relative humidity level. Small wall or ceiling-mounted units are available at reasonable prices and will significantly improve the potential market quality of the vegetables.

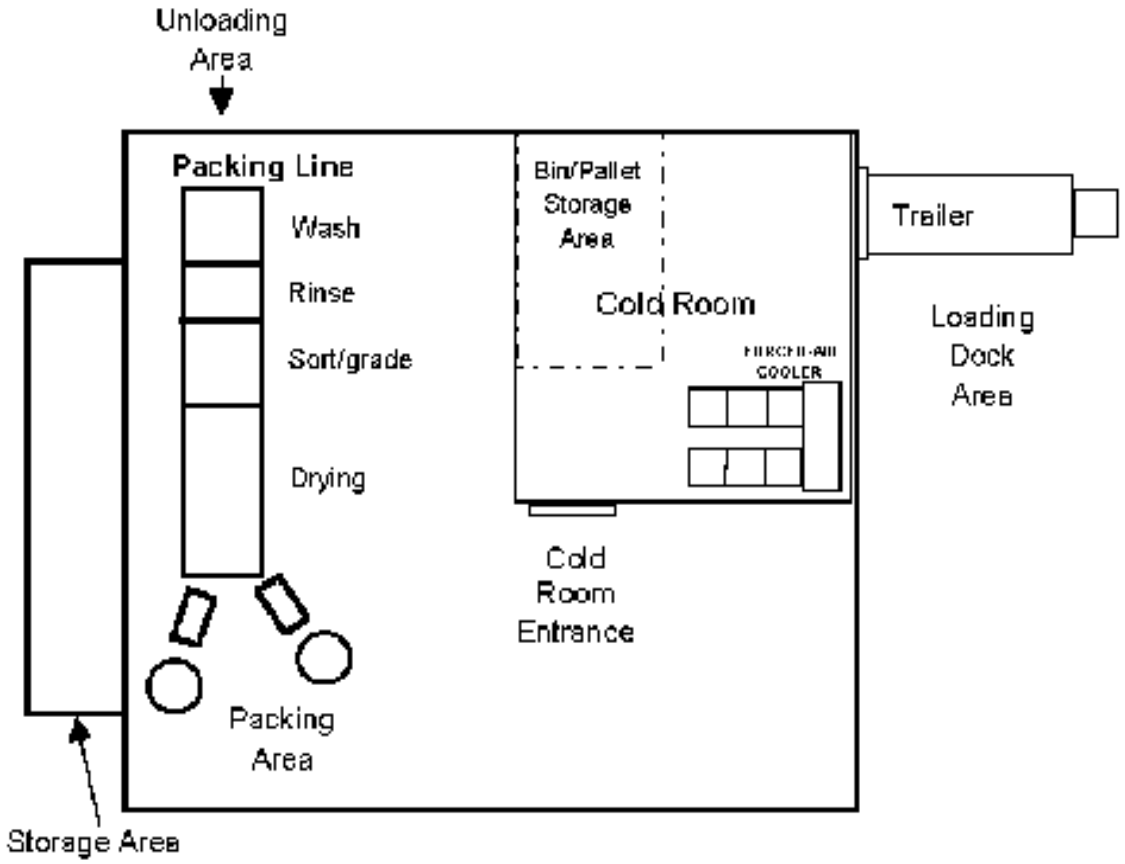
SECTION VII

Suggested Packinghouse Design and Infrastructure Recommendations

SECCIÓN VII

Suggested Packinghouse Design and Infrastructure Recommendations

A suggested general design for a small to medium-sized packinghouse for Asian vegetables is shown below. Individual operations will need to make adjustments and tailor the packinghouse according to their available capital, space limitations, crop selection, and anticipated export volume. Nevertheless, the general layout and flow of product through the different areas should remain similar.



The building should be of sound construction and completely covered. It should be separated from a dwelling house. The floor should be made of concrete to facilitate washing after packing. Floor space should be a minimum of 550 m². Suitable fixtures for grading and handling of the product should be in place, including: tanks for washing and sanitation, tables for grading and sorting, drying tables, and weighing scales.

The specific crops to be packed along with their expected volume will influence the size and design of the packinghouse. A well-designed packinghouse will have an efficient flow of product from the receiving area to the final packed carton loading area. The physical arrangement of equipment and work stations along with the handling volume capacity will determine the efficiency of overall packinghouse operations. Sufficient product handling capacity should be provided for at each step in the packinghouse operations to avoid a bottleneck in product movement.

Once the product has been received and unloaded from the transport vehicle, it may be either temporarily held or immediately prepared for market. If held, the product should be put in a cool, shaded staging area or in a refrigerated storage area. The packinghouse should be designed to have ample space for staging or holding the product at peak harvest volume. In addition, adequate space should be allocated for storage of empty cartons and their assemblage for packing. The assembly operation should be close to where the produce is packed.

The steps in preparing Asian vegetables for market typically include dumping from the field container, cleaning/washing, insect disinfestation (i.e. *Thrips palmii* from certain products), sorting/grading, packing, weighing, and cooling. The flow of product should always be in one direction, with no crossovers. The packed cartons should be cooled and held in a refrigerated storage area prior to loading onto the transport vehicle destined for the airport or sea port.

Suggestions for appropriate infrastructure and recommendations for improving the efficiency of packinghouse operations are listed below. At some of the packinghouse sites the recommendations will be relatively easy and quick to implement, whereas they may be difficult or impractical to do at other sites.

A. Water Source

The water source used for *Thrips palmii* disinfestation and general cleaning processes should be potable and safe to drink. A well or municipal source that can supply 100 gallons per minute at 60 pounds per square inch pressure should be adequate. A 2-inch water main with 1-inch laterals is recommended. Waste water disposal capacity of the packinghouse is an important consideration and must be adequate to meet peak volume demands. Water disposal should always comply with local ordinances and be done in an environmentally responsible manner.

B. Electricity Source

The packinghouse should have a reliable source of electricity and/or a standby generator with enough capacity to run water pumps, electric motors, and refrigeration equipment. The correct voltage and phase of power must be supplied to each device.

C. Lighting

The light level inside the packinghouse should be conducive to efficient packing and product inspection and high enough to avoid worker eye strain. Light intensity should be between 250- to 500-foot candles at the level of the grading surface. Lights should be covered with a safety shield to avoid glass contamination on the product if the bulb shatters.

D. Drying

The produce should be dried as much as possible after washing. However, if the wash water is properly sanitized and the export cartons are adequately waxed, it is not necessary to have a completely dry product surface prior to packing. In order to speed up the rate of drying, either ceiling fans or portable horizontal fans can be used and directed over the product as it rests on a table or remains inside a well-ventilated plastic crate. Horizontal fans generally have a higher air displacement capacity and are more effective in drying. It is recommended to use one high capacity horizontal fan per drying table. Ideally, the fan should be adjustable for speed and rotation.

E. Grading/Sorting

Asian vegetables that are bulk filled directly into the cartons can be more efficiently and quickly packed using a conveyor belt that transfers the product directly as it falls off the end of the belt. Drop heights should be kept to a minimum to avoid product bruising as if falls into the carton.

Ideally, the product drop height should be less than 15 cm. Cushioning of the impact may be provided by having the product roll into the carton at an angle down a chute. Graders should stand on both sides of the moving belt to remove non export quality product and allow the acceptable items continue to move down the belt and fill the cartons. Damaged, diseased, or otherwise non-marketable products should be manually put in a chute or on another belt and taken to a discard area. Elimination belts or grade separation chutes should be nearly flush with the grading area to avoid excessive lifting or arm movement. The most experienced graders should be positioned near the end of the conveyor belt to catch the culls that less experienced graders may have missed.

A refinement of this semi-mechanical type of grading will allow for separation of the product according to size. Dividers may be placed above the moving belt to create separate flow channels. In this way, the small, medium, and large-sized items from the overall lot can be manually placed to move in the appropriate channel. The sized items may then be shunted

directly into individual cartons which receive product only of that one size, or the sized items may flow to separate rotating circular tables for hand packing into the cartons.

F. Cooler Door Openings

Currently, most refrigerated storage rooms have a single doorway for entry and exit. In many cases the width of the door opening is too narrow to allow for orderly and efficient movement of product. In order to facilitate the smooth flow of product in and out of the cool storage area, door openings at least 3 meters (9 feet) wide are recommended. This will provide sufficient space for the movement of a pallet of stacked cartons using a hand jack. Plastic strips should be hung on the inside of the doorway to minimize warm outside air from entering the cool room when the doors are open. Movement of product in and out of the cool storage room should be planned to minimize the time the access doors are open. Ideally, a horizontal sliding door hung on rollers should be installed, although a hinged door opening to the outside is acceptable.

G. Hand Jack for Palletized Cartons

Movement of cartons can be very efficient if they are stacked on a pallet. Depending on the carton size, a pallet may hold between 30-100 cartons. The entire pallet unit can then be lifted and easily moved with a hand jack. This will require a smooth and level floor. Procurement of a hand jack for palletized cartons is recommended for ease of movement and improving loading efficiency at the packinghouse.

H. Sanitary Facilities

Importers in North America and Europe that source product for the supermarket trade have to provide assurance to these retailers that proper diligence was used in ensuring the safety of the food product during the entire period from production to harvest and throughout the steps used in market preparation at the packinghouse. An outbreak of a food-borne illness associated with product from a specific importer or retailer could have devastating financial effects. In order to re-assure the importer and their clientele that product food safety is also a high priority of the exporter, it is important to have clean and easily accessible sanitary facilities for the field and packinghouse workers. Proper sanitary facilities are also required for EUREPGAP and HACCP compliance.

Packinghouse washroom facilities should be sufficient for the number of employees. It is recommended to have one washroom per every 15 workers. Washrooms should not open directly into produce handling areas in order to reduce the risk of contamination from blockage and other malfunctions. Hand washing stations should be located in washrooms so that employees pass them when returning to the packinghouse. The hand washing stations should supply hot and cold potable water, anti-bacterial soap, and disposable paper towels for hand drying. Toilets should be stocked with sufficient toilet paper. Workers should always be requested to wash their hands with anti-bacterial soap following use of the toilet.

Good hygienic practices and sanitation procedures should also be developed in the entire packinghouse. Equipment, floors, storage areas, and refrigeration units should be kept clean and regularly sanitized with the appropriate material to minimize the risk of product contamination with food-borne illness pathogens.

All packinghouse personnel should understand the impact of poor personal cleanliness on produce safety. Workers should wear clothing suitable to the operation in a manner that protects against contamination of produce, packing line equipment, or packaging materials. Outer garments should be free of loose fitting, dangling, or hanging items. Unsanitary personal practices such as scratching the head, uncovered sneezing or coughing, and placing fingers in the nose or mouth may contaminate fresh produce or handling equipment. Employees should thoroughly wash their hands in an adequate hand washing facility before starting work, after each absence from the work station, after using the restroom or blowing nose, and when the hands may have become soiled or contaminated. Personnel with infections, diarrhea, vomiting, open lesions, bad colds, flu, or other contagious diseases should not be allowed to handle produce.

I. Record Keeping

To comply with EUREPGAP regulations and certain North American importer requirements, a program should be developed to track the individual handlers of the product from the point of harvest, through the steps in market preparation inside the packinghouse, and during transport to the eventual receiver. In the event of a food-borne illness outbreak, it is imperative the exporter be capable of tracing back and identifying all people involved in product and package handling. The ability to identify the source of the product from the consumer back to the grower is an important component of good management practices. A coding system should be established to easily and quickly identify the source of the product and packinghouse personnel involved in handling it.

J. Packinghouse Maintenance Program

A well maintained packinghouse environment and infrastructure will allow for the smooth and orderly flow of product, preserving its potential market life. Frequent inspection of packinghouse areas should be part of a regular maintenance program. The following areas should be included in the inspection and maintained in appropriate condition:

- product unloading, loading, and staging areas should be free of garbage and pollutants
- access roadways should be properly graded, compacted, and free of dust
- unloading and loading areas should be have good drainage
- premises should be kept free of rodents, birds, and animals
- adequate ventilation is needed to prevent heat build-up that can lead to worker fatigue
- inlet air vents for ventilation fans should be screened to exclude insects, birds, and animal pests
- windows and screens should be kept in good repair and properly cleaned
- maintain all packinghouse equipment in a clean and sound condition
- clean and sanitize containers, tables, conveyors, belts, and all other surfaces that come in contact with the produce on a daily basis
- remove contaminants such as mud, grease, oil, produce, and debris from packinghouse equipment daily
- discard damaged and muddy cartons to reduce contamination of produce

APPENDIX A

Sources of Supplies and Equipment for La Vega Packinghouses

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Sources of Supplies and Equipment for La Vega Packinghouses

Water chlorination and pH testing equipment/supplies:

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

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

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

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

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

Electronic Weighing Balances
QA Supplies, LLC
1185 Pineridge Road
Norfolk, Virginia 23502
Phone: 757-855-3094
Fax: 757-855-4155

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

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

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

Durand-Wayland
La Grange, Georgia
Phone:
Fax: 706-884-3268

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

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

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

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

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

Temperature/Humidity Recorders
QA Supplies, LLC
1185 Pineridge Road
Norfolk, Virginia 23502
Phone: 757-855-3094
Fax: 757-855-4155

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

Humidifiers
QA Supplies, LLC
1185 Pineridge Road
Norfolk, Virginia 23502
Phone: 757-855-3094
Fax: 757-855-4155

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

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

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

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