COLOMBIA AVOCADOS
Discover a New Avo World

SUPPLY CHAIN & HANDLING GUIDE

BEST PRACTICES MANUAL

TECHNICAL WRITING PROVIDED BY DR JOHN P BOWER

TABLE OF CONTENTS

INTRODUCTION 3

HOW TO USE THE DOCUMENT 4

SECTION 1: PRE HARVEST PRODUCTION CONDITIONS 5

SECTION 2: HARVESTING AND TRANSPORT TO THE PACKING PLANT 8

- Fruit maturity 9
- Harvesting 11

SECTION 3: PACKING PLANT 14

- Arrival and waiting area 14
- Pack line 15
- Fruit dumping 15
- Fruit washing and drying 16
- Fruit grading and sizing 17
- Fruit packing 18
- Fruit cooling 18
  - »Temperature 18
  - »Rate of cooling 19
  - »Humidity of cooling tunnels 20
  - »Effect of packaging design 21
- Storage after cooling 21
- Ventilation of cooling tunnels and fruit holding rooms 21
- General packing plant cleaning and sanitization 22
- Containerization 22
- Quality management 24

SECTION 4: ARRIVAL AND HANDLING AT FIRST DESTINATION 26

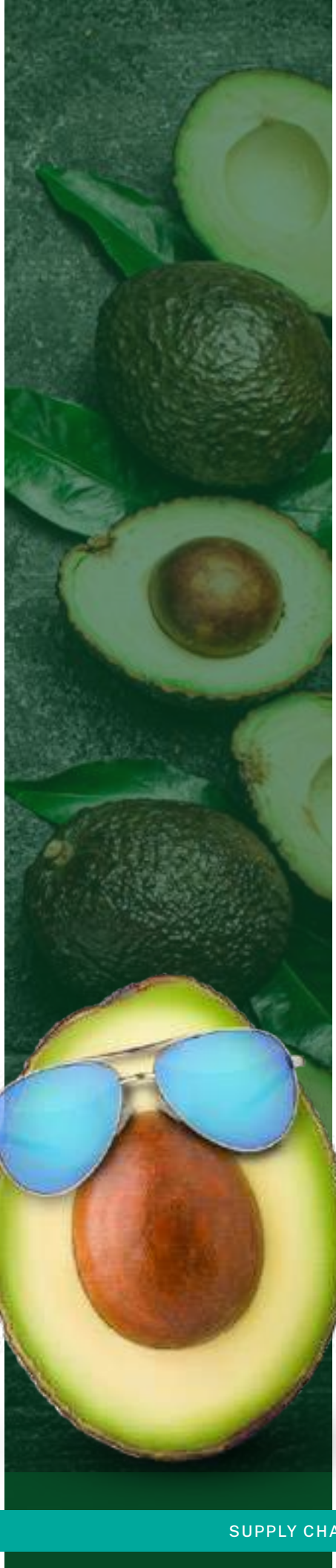
SECTION 5: TRANSPORT AFTER CONTAINER UNLOADING 27

SECTION 6: DISTRIBUTION CENTRES 28

SECTION 7: RE-PACKERS AND FRUIT RIPENERS 30

- Unripened re-paced fruit 30
- Ripened fruit 30

SECTION 8: RETAIL SALES 33



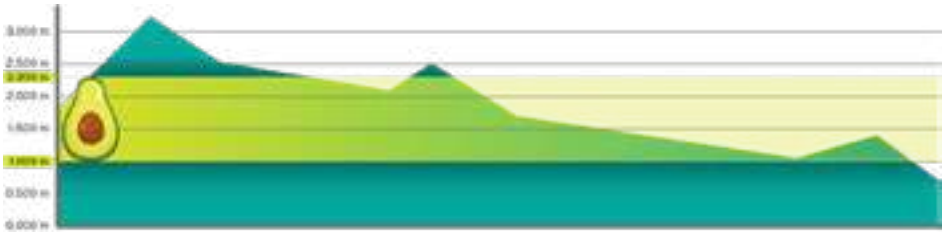
INTRODUCTION

Production and export of avocados from Colombia have increased rapidly in the last few years. As a result of agreements relating to phytosanitary requirements, exports to the USA have increased in importance. This is especially so after the amendment of the phytosanitary regulations, which makes it more practical to comply.

While exporters do have protocols in place for fruit being exported to other destinations, exports to the USA are increasing rapidly from a low base, and also require some different approaches due to the need to integrate the requirements of different markets, as well as packaging, transport and distribution which differ. It would therefore be useful if all producers, packers and shippers have a set of guidelines from which to work.

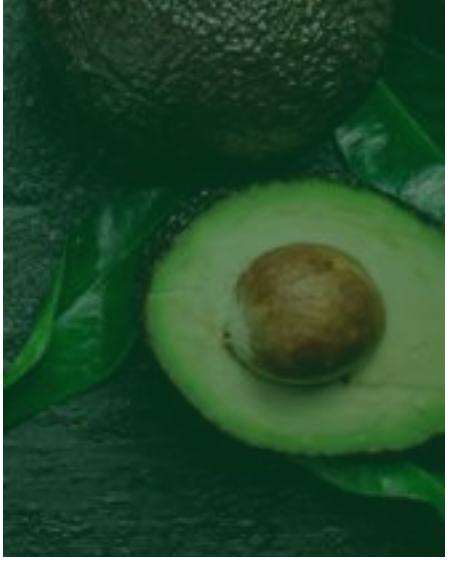
Once fruit arrives in the USA, it may go to many different destinations, and be treated in various ways depending on final destination and the distribution chain before arriving at the final consumer. The fruit may also be mixed with fruit from other sources. This means that there could be many different protocols being used by the various exporters and importers.

Fruit quality management does not start at the packer, but in fact in the field at the producer level, and in addition may be affected by all processes throughout the logistics chain. This is an important concept, because conditions in Colombia are not the same as found in other avocado producing countries. There are a number of notable differences.



The first relates to altitude. Avocados in Colombia are grown at various altitudes varying from about 1000 m to 2300 m. which through temperature, affects the rate of growth and maturity of the fruit. The standards of maturity used in other countries may therefore not be applicable.

Climatic conditions, especially rainfall, are a further complicating factor. Most of the avocados are grown in the high rainfall areas, and are not irrigated. However, the highest rainfall period also coincides with the main harvesting from October to February. This may result in fruit quality problems related to both physiology and fungal pathogens.



Once harvested, fruit needs to be moved to the packing plant. Logistics are often difficult, with road conditions being of importance. Because there are both large as well as many small growers supplying fruit, which may have different physiology due to growing conditions, packers need to be aware of how to manage each consignment of fruit for optimal quality at final destination.

Taking all these factors into account, it is considered useful to develop handling procedures which can be used through the entire production and logistics chain, taking account of the unique conditions under which Colombian avocados are produced. These handling procedures can be used not only by the Colombian producers and packers, but also importers and distributors in the USA.

HOW TO USE THE DOCUMENT

This document is not intended to replace the detailed documents already used by packers and exporters, or the protocols needed for phytosanitary and quality management systems, such as required by the USDA or those of specific retailers. The document is to emphasize issues of particular importance to the maintenance of fruit quality through the entire distribution chain starting at the production level, so that operators can emphasize or add critical aspects to their own detailed operations protocols. It will also help to remove ambiguity, where different companies may be using different protocols within the same distribution chain. The layout is based on the idea that fruit quality starts while still on the tree, and can then be affected by each step in the entire supply chain from harvest to final consumer. Each step in the supply chain needs to take account of the conditions within the previous step, as well as expected conditions further on, and different decisions can be made depending on the situation. The document is intended to highlight critical steps and the choices that can be made, to help operators handle Colombian fruit in the best possible way, for maintenance of fruit quality.

Depending on experience and changing conditions, the suggestions in the document may change or be amended form time to time. The document should therefore be considered to be a **“living document”.**

SECTION 1

PRE HARVEST PRODUCTION CONDITIONS

Fruit quality starts in the field. The best that post harvest conditions can achieve is a maintenance of the quality at the time of harvest. Therefore, the better the quality of fruit at the time of harvest, the better the chance of good quality fruit arriving at the final destination. When the fruit is harvested, it is removed from its source of mineral nutrition, carbohydrates from photosynthesis that provide the energy for the cells of the fruit to continue working, and water which is essential for cells to remain in good condition. The better all of these factors are at harvest, 3 of 44 the longer the fruit will remain in good condition (shelf life), and the better the fruit will be able to withstand the stress of low temperature shipping to the market and storage until final sale. Many of these factors can be modified by the field practices used.

In Colombia, the majority of avocados are grown in fairly high rainfall areas, and it is not normal to use irrigation. Therefore, this aspect will not be discussed further.

Tree nutrition is of particular importance in terms of fruit quality. While the correct balance of all macro and micro elements is important, there are two elements of particular importance for fruit quality. These are calcium and nitrogen.

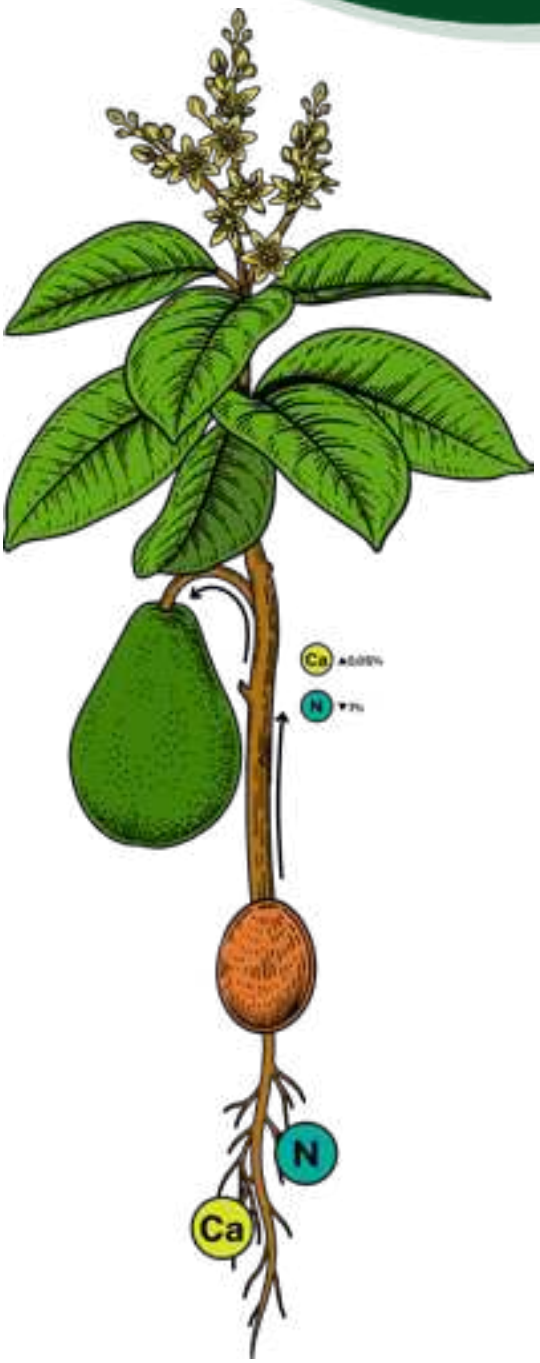
Calcium is of considerable importance, with higher fruit calcium relating to fruit with greater ability to withstand post harvest conditions, and ripen more slowly, providing greater shelf life. Both internal disorders and external damage such as cold damage, are decreased with high amounts of calcium in the fruit. The role of calcium in fruit physiology is complex, but it is believed that from a fruit quality point of view, there is also a structural component relating to cell walls. When fruit softens during ripening, this calcium has to be solubilized and removed from the cell walls by the physiological processes controlling ripening. The higher the amount of calcium, the longer this will take, thus allowing for better shelf life. There is also another physiological role for calcium, and that is in ensuring the stability of membranes. This is most important considering the stress that fruit undergoes after harvest, especially under low temperature shipping and storage.

A factor of considerable importance in Colombia is that of disease management, especially fungal diseases. Due to the high rainfall, especially just before or during the early part of the main harvest period, the potential for post harvest diseases such as anthracnose and stem end rots is high. A pre harvest spray program may be advisable. Root diseases, especially Phythophthora cinamomi, are known to be present. Management of the problem is also advised, as poor root condition will affect fruit yield and quality.

Pest management and inspection is particularly important. Export to the USA depends on each orchard site being registered and complying with the USDA phytosanitary requirements.
The regulations are based on a systems approach, to ensure that quarantine pests (especially tree borers) are prevented from being found in any consignment. This starts in the field and surrounding areas. Regular inspections are essential.

ACTION ITEMS - PRE HARVEST

- Manage nutrition to ensure fruit calcium is >0.05% and nitrogen is <1% one month before minimum maturity
- Ensure good balance of fruit and shoot growth, especially during early fruit development
- Manage diseases to control post harvest and root diseases
- Ensure pest inspections to comply with USDA phytosanitary regulations



Calcium nutrition and movement into the fruit is very specific.
Calcium movement through the tree and into the fruit occurs mainly during the six weeks after fruit set, after which only small changes will occur. There is therefore a very short time when calcium moves into the fruit. This is not dependant on calcium applications at the time, but in fact other factors. Calcium nutrition needs to be considered in relation to these factors. Calcium is taken up through the root tips, (and therefore good root condition is essential), and moves up the tree with the normal movement of water. It is then allocated to fruit and leaves. The calcium allocation to the fruit, and therefore the level at harvest, is considerably controlled by nitrogen, and the strength of shoot growth at the time of fruit set and the six weeks thereafter. Calcium concentration reaches the maximum level at this time, and declines as the fruit grows. The risk of poor fruit quality is substantially decreased if the calcium level is high enough at harvest. It has been determined that risk of internal and external disorders is decreased if the calcium concentration is 0.05% or higher within one month of minimum maturity for harvest.

The calcium concentration in fruit is not directly influenced by calcium nutrition. In fact, most soils have sufficient calcium, but the uptake and movement to the fruit is what controls the amount eventually in the fruit. As previously noted, calcium concentration in fruit is strongly influenced by nitrogen. Nitrogen stimulates shoot growth, and high levels especially at the time of fruit set and early growth (the time for calcium uptake by fruit) are especially problematic. Nitrogen stimulates shoot growth, and high nitrogen at the time of fruit set creates high competition for calcium between new shoot growth and the fruit. This usually results in lower calcium in the fruit. There is also a direct effect of high nitrogen in fruit having poorer quality. At the same time as calcium concentration being 0.05% or greater at approximately one month before minimum fruit maturity, nitrogen should be less than 1% and showing a declining trend.

The nutritional status of the trees can be checked by doing leaf and fruit analysis, and applying the results to the nutrition programme. There is no fixed amount of nutrition, especially nitrogen to apply, as the correct amount to ensure fruit quality as well as suitable tree growth and crop size can vary depending on tree age, condition and crop load. The leaf and fruit analysis is used to make suitable adjustments to the nutrition programme. It is considered that a leaf nitrogen level of less than 3% and preferably approximately 2.3% in 6 to 7 month old spring growth leaves is optimal.

Correct balance of tree growth and fruit number is necessary to ensure suitable tree and fruit nutrition, as well as regular crop size without, as far as possible, high and low crop years. Some factors such as climate can not be managed, but apart from the correct nutrition, a regular pruning programme is needed. This will ensure sufficient sunlight for photosynthesis as well as flower development. Shaded areas generally do not produce good flowering and fruit set, which affects yield, shoot:fruit ratio and fruit quality.

SECTION 2

HARVESTING AND TRANSPORT TO THE PACKING PLANT

Fruit quality starts in the field. The best that post harvest conditions can achieve is a maintenance of the quality at the time of harvest. Therefore, the better the quality of fruit at the time of harvest, the better the chance of good quality fruit arriving at the final destination. When the fruit is harvested, it is removed from its source of mineral nutrition, carbohydrates from photosynthesis that provide the energy for the cells of the fruit to continue working, and water which is essential for cells to remain in good condition. The better all of these factors are at harvest, 3 of 44 the longer the fruit will remain in good condition (shelf life), and the better the fruit will be able to withstand the stress of low temperature shipping to the market and storage until final sale. Many of these factors can be modified by the field practices used.

The harvesting operation as related to final fruit quality is complicated in Colombia. As will be outlined later, a carefully integrated harvest plan between producer and packer is essential to optimize the fruit quality in the market. This is because the packer (and in fact also marketer) needs to know about factors affecting fruit quality in each consignment received at the packing plant. The previous section discussed factors such as calcium and nitrogen contents in fruit. In addition, there are fruit maturity and other tree condition factors of importance. While these are easy to obtain in large organizations who both produce and pack, it is not as easy in the case of many small to medium size producers who do not have their own packing plants. There are many such situations in Colombia. Nevertheless, it is very useful for the packing plants to work together with producers to know the characteristics of a particular production site's characteristics. This will help considerably to determine potential fruit quality and the risk profile of the fruit for quality defects such as chilling damage, grey pulp, stem end rot and anthracnose. By knowing the quality potential and risk factors, the packing plant can better decide on the most appropriate cooling and shipping conditions, as well as which markets the fruit should be sent to. Many packing plants pack for a number of different markets, which require different shipping times and conditions, and fruit destined for the USA will need to be included in the total risk profile of all fruit to all destinations.

As previous noted, an analysis of fruit mineral contents, especially calcium and nitrogen, is very useful in predicting risk for quality defects, especially chilling damage and grey pulp. They may also be an indicator of shelf life and ripening physiology, and although specific values of nitrogen and calcium are not known, there is good evidence that the progression of fungal pathogens such as those causing anthracnose and stem end rot may also be affected. It would be a good idea to have analysis from early in the season to the time of picking, to see the trends in changes as well as actual levels. However, an analysis for each orchard at least one month before minimum maturity is advised. Levels of nitrogen at less than 1% and showing a decreasing trend, plus calcium at 0.05% or higher, would indicate good quality fruit. These factors can be included in the packing house marketing and distribution plans, with higher risk fruit going to closer markets, short storage periods or food service where fruit are to be ripened and used within a short time.

Where possible, packing plants should also use the known history of the section to be harvested, to help plan packing, cooling and shipping.

FRUIT MATURITY

Fruit maturity is usually determined by measuring dry matter. The legal requirement for sale of avocado fruit in the USA is a minimum of 21.8%. This is the level considered to be required for the fruit to ripen normally. However, the use of dry matter to determine maturity is an indirect method, based on the fact that there is a known relationship between oil accumulation and dry matter. The oil accumulation is considered to have a closer relationship to physiological maturity, but is much more difficult to measure. The rate of oil accumulation also differs, depending on climate (especially temperature, sunlight and rainfall). The differences in altitude at which avocados are grown in Colombia and the effect this has on climate are especially important. Work done in Colombia showed considerable differences in oil accumulation and the relationship with dry matter at different production sites. This work showed that dry matter of 21.8% was inadequate to ensure correct ripening of fruit from all areas, some requiring considerably higher dry matter. It is therefore strongly suggested that a dry matter of 23% be used as a minimum standard to ensure correct ripening. This has been done in a number of other countries, and it is essential that Colombia ensures good quality fruit in the market in order to compete.

When considering fruit maturity determination, it needs to be remembered that the test is from a sample of very few fruit. It is therefore necessary to try and ensure that the test sample is as representative of the fruit on the tree as possible. In addition, because the test relies on measuring the amount of water in a sample, it is very easy to induce errors if one is not very careful in using the standard technique, and thereby over estimate the dry matter.

The details of the recommended method for dry matter determination are as follows:

This procedure should be used for all fruit, including determining dry matter for fruit in the field or after arrival at the packing plant, and includes all sizes.

Sample size:

- For orchard sampling, take at least one sample for every 10 hectares.
- For the packing plant, take at least one sample from each group of fruit delivered and take additional samples if the field or producer is different.
- Each sample consists of 5 avocados, and for each fruit of the sample the DM determination must be carried out separately.

Sub-sample preparation:

- Cut each fruit in quarters, first in half from top to bottom (peduncle towards the distal edge), then cut again in the same direction to obtain the quarter.
- Select one quarter, and peel the fruit.
- Slice the fruit with a knife or peeler to obtain approximately 10 g of fruit.

- Weigh the sample to obtain the initial weight. NOTE: It is essential that the weight be recorded as quickly as possible after cutting, as the fruit slices rapidly lose water which will create inaccuracy in the dry matter determination.
- After recording the initial weight, dry the fruit in a microwave oven to constant weight. Ensure that the sample does not burn. The time needed will depend on the power of the oven and the number of samples being dried at the same time.
- Record the dry weight of the sample, and calculate the % Dry Matter = (dry weight / fresh weight) * 100

Each fruit within a sample should be should be tested separately. It is strongly suggested that the average of each 5 fruit sample be 23% or greater, and that no fruit should be less than 21.8% for the decision to harvest. While the minimum dry matter for harvest is required for legal as well as quality purposes, a maximum should also be considered. The higher the dry matter the more likely there will be post harvest disorders such as grey pulp, short shelf life and possibly increased anthracnose development. Where possible, a maximum dry matter of 30% is suggested. These factors should be taken into account by marketing companies, when deciding the ratio between risk and reward for early and late season harvest.

Knowledge of the dry matter is important not only for legal requirements but also for the packing plant to make the correct decisions concerning cooling and shipping temperature, as well as to which market the fruit is best suited. This is particularly important where a packing plant is packing for a number of different producers who may have differing fruit characteristics.

For fruit dry matter testing to be effective, the following protocols are suggested:

- Testing for dry matter should be done starting a few weeks before harvest is planned, so that good planning can be done. It is helpful for a packing plant to know the maturity in advance, and also to arrange to pack as much fruit as possible with a similar maturity. This is especially important for packing plants packing for multiple producers. It is useful to try as best possible, not to have mixed maturity fruit within a box, pallet or consignment. The ripening characteristics will be different, and mixed maturities will result in checker board ripening within a box, and create great difficulties for correct choice of cooling, as well as downstream for fruit ripeners, re-packers and within the retail sector.

- It is suggested that at least 5 fruits per 10 ha block with the same age and tree condition should be sampled. Fruits should be sampled from the side of the trees with most shade and represent the range of sizes to be picked.

- Fruits must be taken to the testing facility as soon as possible, and must not be left in a hot vehicle for any time. Fruits lose water after picking, and the longer the fruit is left before testing, the more the results can be affected.

- A decision to harvest should only be made once the average of all the 5 fruit per 10 ha sample are acceptable for export. While the legal requirement for fruit in the USA is 21.8%, packers and marketers in many countries consider the minimum maturity for Hass fruit to be 23% dry matter, and as explained above, for Colombian fruit this may be particularly important. In addition, it is suggested that no fruit in the sample should be less than 21.8% dry matter. If that is the case, the decision to harvest should be delayed for a week, and the test then repeated.

- Testing should also be done once fruit arrives at the packing plant, so that the plant is sure the fruit is of acceptable maturity, as well as for planning cooling and shipping temperatures.

- Select 5 fruit from each size represented in the block, orchard or consignment after it has arrived at the packing plant from the field. It is important that different sizes are considered separately, because there can be a large difference in dry matter between small and large fruit, especially at the start of the season.

- Use the microwave method of fruit moisture measurement. ***See details above.***

HARVESTING

Once fruit are of acceptable maturity as determined by dry matter, harvesting can begin. Harvesting is the first part of the fruit logistics process, and errors or rough handling causing fruit damage will have serious quality consequences later in the chain. The packing company needs to help plan what fruit is to be harvested and from which fields.

In order to make it easier to decide on cooling protocols and match fruit with the optimal markets for the particular fruit, as well as group fruit as far as possible into final consignments of similar fruit characteristics and quality, the packing plant needs to carefully plan which fields and fruit sizes (if selective picking is to be done) should be harvested for delivery to the packing plant. This is especially important if the packing plant is packing for many small to medium sized producers. The end destination for the fruit, especially if the fruit is to be ripened before sale or processing, needs to receive fruit of similar characteristics and quality in each consignment.

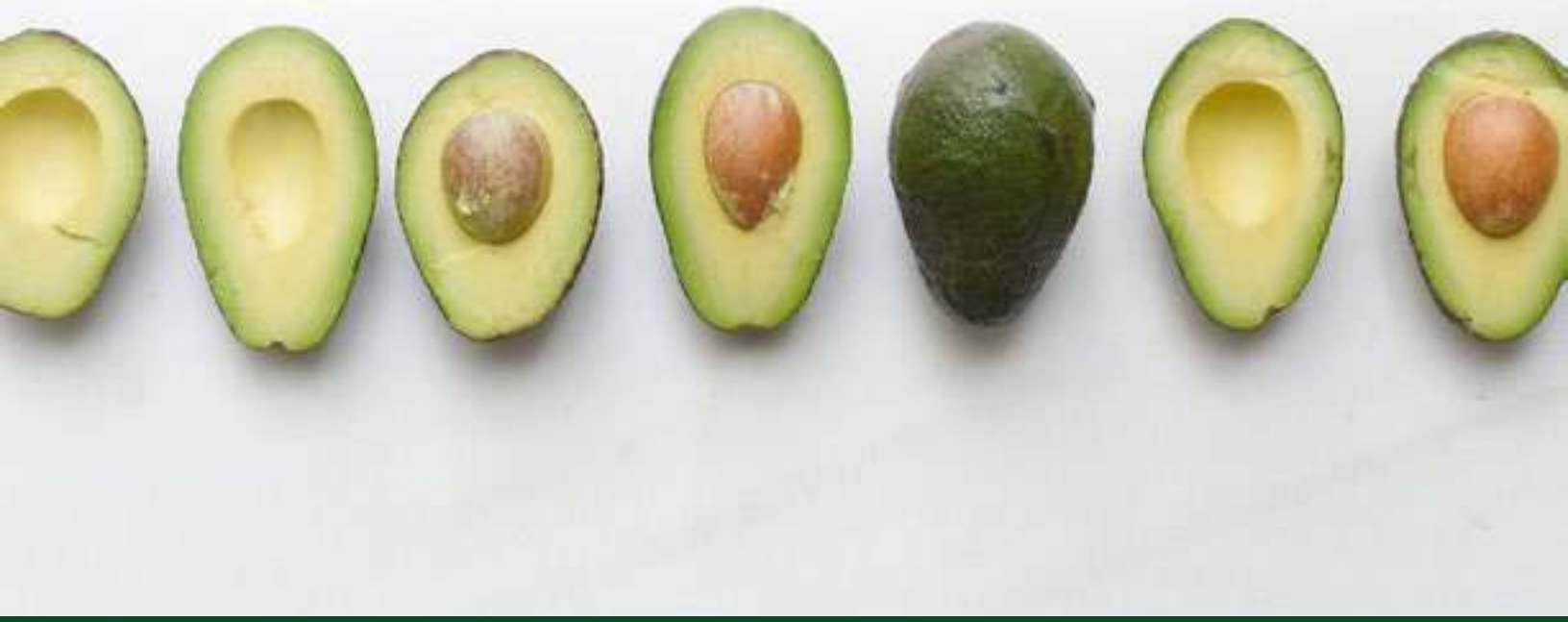
Hass fruit can vary in the roughness of the skin depending on tree age and climatic conditions. The rougher the skin, the more the lenticels can be damaged during harvesting and processing. Any damaged lenticels will cause the cells around the lenticel to lose water, die and be more likely to be seen as small black spots or even develop further to become more extensive during cooling and shipping, and may be considered to be chilling damage. This will result in the market considering such fruit as having external quality defects. Colombian fruit has been noted to be susceptible to this disorder. It is therefore necessary to put in place procedures to decrease the extent of the damage. It is also possible that the fungi causing anthracnose, will develop more easily in such damaged spots. Fruit needs to be handled very carefully during harvest, and workers need to be specifically trained to know that their actions are very important. Damage may not be seen in the field, so workers need to be made aware of how important it is for them to handle fruit carefully. Picking teams need to be trained before the start of the main harvesting season and if new members join the teams. Colombian fruit may also be harvested during the rainy season. Fruit will tend to be harder and more likely to become damaged. This is especially so if the fruit is wet when harvested. Whenever possible, fruit should not be harvested in the rain or preferably when still wet. Lenticel damage and larger black spots are one of the noted defects in many markets. Fruit which originates from a blossom separate from the main blossom period (sometimes referred to as “flora loco”) appear to be especially susceptible to lenticel damage and black spot development.To decrease the potential damage during harvesting, the following actions need to be taken:

- Train picking teams before the main harvest season and follow-up with reminders during the harvest season.
- Try to not pick wet fruit or during rain.
- Set realistic picking tasks so that workers can take sufficient care of the fruit and not handle the fruit too fast.
- Supervisors need to regularly check the picking process and take control samples to check on fruit condition.
- Picking scissors need to be regularly disinfected, to decrease the incidence of stem end rot. Also, it is important that fruit be clipped and not snap picked. Snap picked fruit has a much higher chance of developing stem end rot.
- Fruit needs to be carefully placed in field bins or boxes. Fruit will easily bruise or damage if dropped into the bins or boxes.
- While large field bins and smaller picking boxes can be used, there is some evidence that full field bins can result in more fruit bruising and lenticel damage if road conditions to the packing plant are poor. This is especially so if the fruit is very hard (turgid) due to rain and cool weather.
- Keep the field bins or picking boxes in the shade until the fruit can be transported to the packing plant. This should be as soon as possible, unless it is cold or wet, when it may be better to allow the fruit to wait for a few hours so that it loses some turgidity and is less likely to be damaged during transport. In accordance with the phytosanitary regulations for the USA, fruit must be moved to the packing plant within 3 hours of harvest, or must be protected from fruit fly infestation.

It is important that due to the phytosanitary regulations for fruit destined for the USA, any fruit on the ground must not be placed in the picking bins or boxes, and must be destroyed separately. Constant orchard sanitation is also needed and any fallen fruit removed at least every 7 days.

ACTION ITEMS - HARVESTING AND TRANSPORT TO PACKING PLANT

- Ensure sufficient fruit maturity before starting harvest
- Preferably use sample average of 23% dry matter as basis for maturity
- Only harvest if all fruit in sample of 5 fruits per 10 ha, each measured separately, are above 21.5% dry matter
- In determining dry matter, very important to weigh fruit immediately after cutting sample
- Ensure very careful picking to decrease chance of lenticel damage
- Sterilize picking scissors between trees and never snap pick to decrease risk of stem end rot
- Preferably do not harvest in rain or if the fruit is wet
- Consider not filling picking bins if danger of lenticel damage is high (especially if cold and wet)
- Keep fruit as cool as possible and transport to the packing plant as fast as possible except if danger of lenticel damage is high. Then stand fruit for a few hours first but not for longer than 3 hours or must be protected from fruit fly infestation



SECTION 3

PACKING PLANT

ARRIVAL AND WAITING AREA

The entire packing plant, including the holding area for arriving fruit must, in accordance with USA phytosanitary regulations, be an insect exclusionary structure.

The arrivals area and holding room should preferably be cooled with the room being between 10°C and 15°C (50°F and 59°F). It is further advantageous if the room is humidified. This decreases water loss from the fruit, and helps limit the effects of lenticel damage which may have occurred between harvest and arrival at the packing plant. Deceasing the temperature to the stated level will also help to acclimatize fruit to the later cooling to shipping temperature and increase the efficiency of cooling.

If the holding area is not cooled, it should at least have fans to move the air and create some cooling.

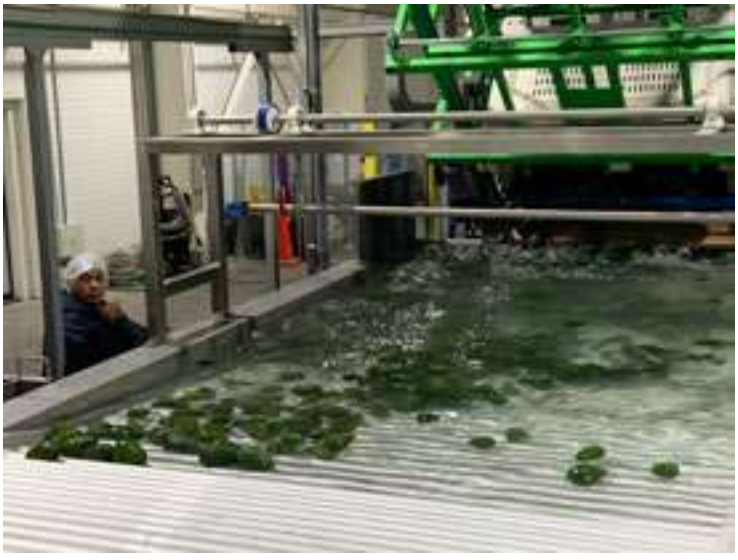
Fruit needs to be moved from the holding to the processing and packing area as soon as possible. USA phytosanitary regulations require fruit to be packed within 24 hours of harvest, and from a fruit physiology (and quality) point of view, fruit should be packed and cooled to shipping temperature much sooner. This will be further discussed in the cooling section.

PACK LINE

After the harvesting and transport to the packing plant, certain sections of the pack line are potentially the most damaging to the fruit, and result in considerable lenticel damage. It is advisable to check the pack line for possible points of damage (especially lenticel) before the main packing season as well as regularly during the packing season. Each section of the pack line should be checked separately. Fruit samples should be taken and checked especially for lenticel damage, after each of the sections for fruit dumping onto the line, the washing section, drying section, grading and labeling, sizing and packing. Sections where fruit bump and possibly rub against each other, drop onto belts or are brushed are especially areas to check.

FRUIT DUMPING

Fruit can be dumped onto the pack line from the field bins or picking boxes using either a dry dump or water dump. While dry dumping is the easiest to operate, there is the most possibility of fruit damage. Fruit dropping onto each other or rubbing against each other before moving onto an elevator or belt before moving into the washing area, is the most common cause of damage in this area. Careful control of the fruit dump rate is critical to preventing excess fruit on the dump area and rubbing against each other. Control of the dump rate (for dry and wet dumping) is also critical in managing the volume of fruit moving further down the pack line. Of particular note, is the ability of packers to pack the volume of fruit arriving at the packing points. If too much fruit arrives at the packing points, there may be no option but to remove fruit at the packing points and replace it at an earlier point on the line. This extra handling of fruit is certain to cause further damage to lenticels.



Water dumping is considerably better than dry dumping, as bruising and rubbing of fruit against each other at the dump point is largely prevented. However, if using a water dump, it is essential that the water be cleaned through a filtration system to remove dirt, as well as including a disinfectant to prevent build-up of post harvest pathogens. The usual disinfectant is chlorine, maintained at a concentration of 50 ppm chlorine dioxide or 100 to 150 ppm calcium hypochlorite at pH 6 to 8. Active chlorine, especially if calcium hypochlorite is used, can rapidly be de-activated by dirt from the fruit, and needs to be regularly checked throughout the day. The use of a water dump can also be used to partially cool the fruit through hydrocooling. Cooling the fruit slightly increases the efficiency of later cooling and has a beneficial physiological and quality effect by decreasing fruit temperature sooner. A water temperature of 4°C to 6°C (39°F to 43°F) is suggested.

FRUIT WASHING AND DRYING

The washing and drying section is the most likely in the entire pack line to cause fruit damage, especially to the lenticels. The main cause of the damage is the use of brushes. It is suggested that the minimum number of brushes needed to clean fruit be used, and should be as soft as possible. A high pressure washing unit using an operating pressure of 100 to 250 psi can be considered as an alternative to brushes. If fruit requires considerable cleaning of, for example, spray residue, a detergent may also be applied, followed by a further water rinse. However, detergent can remove some of the natural wax on the fruit which can increase later water loss and possibly decrease fruit quality. Included at this point in the wash line, should be a fruit sanitizing agent. This is important from a food safety point of view, but also needed as part of a post harvest disease management strategy. This is particularly important for Colombian fruit due to the high potential for post harvest disease caused by anthracnose and stem end rot fungi infections in the high rainfall areas. Peroxyacetic acid (PAA) is often used, at a concentration of 100 to 150 ppm. There are various suppliers of this product, and active ingredient concentrations differ. Care needs to be taken to adjust concentrations depending on the product source. There are also other anti-fungal products supplied by various companies. Additional fungicides may be a problem, as markets such as the EU no longer permit certain fungicides, and if used on a pack line can be very difficult to remove and prevent contamination. As much of the Colombian crop is exported to markets other than the USA, this is a particular concern.

Following fruit washing and anti-fungal treatment, fruit need to be dried. The standard drying unit uses hot air drying at a temperature of 35°C to 40°C (95 to 104°F). In addition, brushes are used to help remove water. This section also has a high potential for causing lenticel damage. As few brushes as possible, and as soft as possible should be used. An alternative is to use an air knife for drying, as this may eliminate most if not all brushes in this section. Note that an air knife should be specifically set up for fruit drying, and is not a high volume air blower.

FRUIT GRADING AND SIZING

The processes used for fruit grading (manual, optical or a combination) and sizing, which is normally done by weight, are not high risk for fruit quality. Nevertheless, packing lines often have belts that end in fruit dropping to a lower level or the sizing unit dropping fruit onto a belt relating to that particular size to convey it to the packing station. These are all potential damage zones that should be checked. Sizing is done by weight. However, fruit loses water during cooling and shipment, and therefore it is necessary to take this into account when setting the sizer. An expected 2% loss in weight may be a reasonable assumption. There also needs to be some adjustment of size to make sure boxes are correctly filled so that fruit is not loose, but also so that boxes are not over-filled. Over-filling will cause fruit to be bruised, and pallets will not stack correctly, leading to unstable pallets. Fruit shape is often the cause of problems. Sizing may need to be re-set for different fields, and especially if a packing plant is packing for different producers. There is some evidence that the boxes used for the USA are problematical in ensuring correct sizing for each size packing pattern with respect to ensuring fruit do not rub against each other resulting in damage. Extra care in setting sizing therefore needs to be done for USA destined fruit. The following sizes can be used as a guide, for the USA.

Count Size	28	32	36	40	48	60
Weight (g) at destination	390-447	333-397	289-354	269-317	213-269	177-213
	70	84				
	135-177	106-134				
Count Size	**28**	**32**	**36**	**40**	**48**	**60**
Weight (g) at packing	399-458	343-398	320-342	283-319	218-282	183-217
	70	84				
	137-182	109-136				

FRUIT PACKING

The most important issues in packing are to make sure fruit is not damaged by packers and that the sizing is correct for the count size and required packing pattern ***(see comments in section on sizing).*** Fruit too large or of a shape that does not easily fit the packing pattern are the most usual problems. Packers should be trained to recognize this, and if found, need to be able to alert supervisors to alter the sizing. Not only can further lenticel damage occur, but fruit can be bruised, which will most likely only be seen when it ripens.

FRUIT COOLING

Fruit cooling is possibly the most critical process in the entire packing plant procedure, in terms of its effect on later fruit quality. It is the first point in the cold chain logistics, and if not correctly done, will affect the entire chain and the eventual fruit quality. To illustrate the importance, the Q_{10} principle is often stated. This is that for every 10°C increase in temperature the shelf life of the fruit halves. All fruit must therefore be adequately cooled to the lowest possible temperature which does not cause chilling damage. In order to achieve this, most packing plants use forced air cooling tunnels for initial cooling to the designated target temperature, followed by static cooling in holding rooms to wait for container loading and shipping.

The cooling process includes a number of critical components in order to achieve the correct target temperature for the particular fruit, while ensuring the fruit is not damaged. Any damage will likely be visible later in the market as extensive lenticel damage, traditional cold damage black spots which includes damaged skin between lenticels and possibly internal damage visible as a grey or black flesh. Important factors are as follows:

TEMPERATURE

The temperature to which fruit is to be cooled in the cooling tunnels depends on:

- Dry matter
- Distance to destination
- Potential storage requirement
- Harvesting season, early or late for the particular fruit origin (see also the comments relating to altitude and maturity in the section fruit maturity)
- In Colombia the main harvesting season or a smaller harvesting season based on a different flowering (“flora loco”). The physiology differences are not understood but may involve calcium
- Risk of fruit for cold damage (see also section under harvesting relating to mineral content, especially Calcium and Nitrogen)

The decision as to what target temperature to use is usually based on dry matter, and approximate dry matter to temperature targets are available. However, these also need to be adjusted depending on the other factors outlined above. Based on dry matter, approximate temperatures are, + 1°C (2°F):

- Dry matter < 23% use 7°C (44.5°F)
- Dry matter 23-26% start at 6.5°C (43.5°F) decreasing to 5°C (41°F)
- Dry matter >27% use 4.5°C (40°F). For this temperature careful consideration is necessary, taking all risk factors into account, and noting that containers can often deliver air slightly lower than set temperature

Do not adjust low dry matter fruit (<23% if packed) or early season fruit to lower temperature than stated above, as chilling damage may occur in fruit stored for longer than 2 weeks. At low dry matter the temperature indicated will not result in premature ripening provided there are no significant cold chain breaks. The closer the market or shorter the intended storage period, the more flexibility there is for cooling fruit to a slightly higher temperature than those shown. The USA market is relatively close for Colombian exporters and therefore maintaining the lowest temperature is not as critical as may be the case for more distant markets. Adjustments are also necessary depending on risk of fruit for chilling damage, based on the risk factors shown above.

For optimum cooling and quality management, it is necessary to have pallets of fruit with as homogeneous dry matter as possible being cooled together in a cooling tunnel. The organization of packing to ensure that groups of fruit as homogeneous as possible are placed together in pallets should be done. This is especially important if the packing plant is packing for multiple producers which may have fruit of different maturities. There may also be different dry matter in fruits of different count sizes, and this should be taken into account. The better the cooling process can be done, the better the fruit quality and shelf life.

RATE OF COOLING

The cooling process involves the final target temperature as well as the rate of cooling. The objective is to cool the fruit as fast as possible without causing any chilling damage. A rapid rate of cooling can decreases the amount of water lost by the fruit during cooling due to the rapid fruit temperature decrease and also allows for a greater throughput of the cooling tunnels, which has financial advantages. However, if cooling occurs too fast, a wind chill effect can result, causing the fruit peel to cool substantially below the target temperature and increase water loss due to high air volumes moving across the fruit. This can cause cell damage which is seen later as chilling damage.

The cooling time required depends on starting fruit temperature, package design and type, set and objective temperature, air flow rate and number of pallets being cooled (usually 20). An air flow rate of 1 l/s/kg when cooling 20 pallets is suggested. This can be increased to decrease total cooling time, but fruit water loss will increase. Additional humidification of the air is strongly suggested (see section below). Avocado fruit is also a dense medium, and therefore internal temperature decreases more slowly than the external temperature. If cooling is too rapid, again the external temperature of the fruit may decrease to chilling damage levels before the internal temperature has reached the desired level. The objective, therefore, is to cool at a rate that allows internal heat exchange without excess external temperature decrease. In order to manage the cooling process, make considerable use of temperature sensors, and monitor the change over time.

Sufficient temperature sensors should be placed in the fruit pulp both inside the rows of pallets (side of pallet facing plenum) and outside, at the front, centre and back of the row of pallets to monitor the cooling, so as to ensure that pulp temperature reaches the desired point within all pallets. If possible, measurement of fruit skin temperature is also very useful. The change in pulp temperature of the Sufficient temperature sensors should be placed in the fruit pulp both inside the rows of pallets (side of pallet facing plenum) and outside, at the front, centre and back of the row of pallets to monitor the cooling, so as to ensure that pulp temperature reaches the desired point within all pallets.

If possible, measurement of fruit skin temperature is also very useful. The change in pulp temperature of the fruit should be monitored. The rate of cooling between the back and front of the pallet rows will differ slightly, so the sensors will not reach the objective temperature at exactly the same time, but the cooling rate is correct when all sensors reach the set objective temperature at approximately the same time. It is particularly important that some sensors do not show a temperature considerably below the set temperature, as chilling damage may then occur to some of the fruit. This is particularly so for the skin temperature sensors. This would be an indication that the rate of cooling is too rapid. It is also particularly useful to check the differential as well as rate of temperature change between fruit on the outside and inside of pallets. If fruit temperature on one side of a pallet is considerably different to the other, and one side is decreasing much more rapidly than the other, it is a good sign that air flow is too rapid. This could lead to chilling damage on one side of the pallets or inadequate cooling on the other. Air flow rate should then be decreased. A differential of 0.5°C (1°F) is acceptable. Do not rectify this problem by reversing air flow during the last few hours of the cooling cycle, because that may result in fruit in the centre of the pallets not being cooled adequately. When setting the air delivery temperature, do not set the temperature lower than 0.5°C (1oF) below the intended target fruit pulp temperature. Do not allow external fruit temperatures to go below the set temperature, as this could cause damage. In practice, it is acceptable to end the cooling cycle when 80% of the pulp sensors have reached the target temperature and the remaining 20% are within the 0.5°C (1°F) variation.

HUMIDITY OF COOLING TUNNELS

As stated above, humidification of the cooling tunnels is strongly advised. Incoming cold air is often much dryer than expected. As air moves over the cooling unit, dew point may be reached as the air cools, resulting in condensation. This water is then effectively removed from the air, making it much drier than before it moved over the cooling coils. The air arriving at the surface of the fruit is thus much drier than that surrounding the fruit lenticels, because just below the lenticels the air is at 100% relative humidity. Water moves from the high concentration in the fruit, to the lower concentration in the air, causing a loss of water from the fruit. This process is repeated each time air moves over the cooling coils and then over the fruit. The most rapid loss of water from the fruit will be for the first 1 to 2 hours of cooling, when the fruit is substantially warmer than the air passing over it. The dryer the air, the more water will be lost from the fruit. Lenticel damage will increase this loss. Cells closest to the lenticels lose more water, and become stressed, and more sensitive to cold damage. The overall result is an increased chance of chilling damage. Measurement of the relative humidity in a cooling tunnel will often show a rapid decrease during the first 2 hours of cooling followed by an increase. This shows a loss of water in the air, followed by replacement from the fruit.

The solution to the problem is to humidify the air in the tunnel. This can be done by installing mist sprayers to add water to the incoming air. If this can not be done, wetting the tunnel floor before cooling starts, will help. The ideal relative humidity should be maintained at approximately 85 to 95%.

EFFECT OF PACKAGING DESIGN

Both the size and ventilation through different forms of packaging (box design) affects the rate and efficiency of cooling. The standard double layer with interleaf used for the USA is considerably different in ventilation characteristics to the 4 kg closed or open top box used for Europe, and even more so compared to plastic crates. Colombian packing plants will most likely be packing for export to Europe at the same time as packing for USA customers, and therefore many of these box designs may need to be cooled at the same time. Because of the considerably different air flow characteristics of the boxes, it is highly inadvisable to try and cool pallets of different types of packaging at the same time. The standard USA box is probably the most difficult to cool, and if mixed in a cooling tunnel with pallets of other box types, it is likely that either the USA pallets will be inadequately cooled, especially in the centre of the pallets, or pallets destined for Europe or other markets will be cooled to the point of possible chilling damage if the USA pallets are adequately cooled. If USA pallets are not properly cooled, the hot spots in a loaded container can result in fruit starting to ripen, with serious consequences for quality.

STORAGE AFTER COOLING

The rooms used for holding fruit awaiting shipment, are normally set at the temperature the fruit is to be shipped at. It is also desirable to hold fruit for the shortest time possible. It should also be noted that the holding room operates on a static cooling basis, and therefore pallets need to be adequately cooled before being placed in the holding room.

Ideally, the holding room should contain a stacking system to ensure that pallets are placed in an orderly manner, and have at least a 10 cm (4 inch) gap between them so as to ensure good air flow and maintain the set temperature. The cooling system fans should be placed in a way that ensures good air flow around the pallets.

In term of temperature, particular care should be taken when dry matter and other factors as outlined above, indicate a decrease in cooling and shipping temperature. If fruit requiring a higher temperature is still in the holding room, keep the temperature at the higher temperature. Further, do not use a delivery air temperature set at less than 1oC (2oF) below the target temperature.

As with the cooling tunnels, the holding room should ideally be humidified. The same principles as with the cooling tunnels applies.

VENTILATION OF COOLING TUNNELS AND FRUIT HOLDING ROOMS

As large amounts of fruit and movement of people occurs within the cooling areas of packing plants, over time through the packing season, it is possible that there will be a build-up of CO_2 in the cooling tunnel and holding room areas. Of even more importance, some increase in ethylene from fruit will occur. The latter is of particular concern because it will affect later fruit quality. Many packing plants also hold quality control samples in the holding rooms, and this fruit will also produce CO_2 and ethylene if kept long enough. All cooling tunnels, transfer areas and holding areas should be checked regularly for a build-up of these gasses. Ethylene should preferably be kept at levels below detection limits, but at least below 0.1 ppm. The problem becomes more important to consider late in the main packing season when considerable amounts of fruit have been in the plant, and is also more mature.

For ethylene, commercial scrubbers are available, and fresh air ventilation should also be used to prevent a build-up of both ethylene and CO_2. Even if scrubbers are installed, it is still useful to vent air with fresh air on a regular basis. Also, care needs to be taken at the loading dock. Even if there is a seal between the containers and the loading area, it should be ensured that trucks are not kept running during opening of the loading doors as ethylene in the truck exhaust can leak into the loading area and the container. Wait for a number of minutes after engines are switched off before opening the loading doors.

GENERAL PACKING PLANT CLEANING AND SANITIZATION

All packing plants will have protocols to ensure compliance with HACCP programs, the Food Safety Modernization Act (USA fruit) and a number of others as required by various customers. Food safety is of particular concern, and all factors relating to the packing plant, workers and fruit, which may result in pathogens entering the pant need to be taken very seriously. However, there are some aspects that go beyond the requirements. In the case of Colombia and for fruit particularly destined for the USA, the care needed to ensure insect proof packing plants to comply with the phytosanitary regulations needs to be particularly considered.

Within the packing plant, general cleanliness and neatness and orderliness is needed to ensure a culture of care and attention to detail. This helps to encourage workers to take care in handling fruit, which in turn assists in maintaining quality. This is an issue of operational culture not necessarily contained in the operational protocols, but one which can make a large difference to the overall quality of fruit delivered.

CONTAINERIZATION

There are a number of factors in containers that relate to final fruit quality. These often are in addition to the standard container loading procedures, which all companies have.

It is absolutely essential that all pallets are checked for temperature before loading, and that no pallet that is not at or below the target set temperature be loaded. Hot spots within a pallet or a pallet within the total load, can result in the fruit starting to ripen during shipping. If this occurs, not only will the container atmosphere in terms of CO_2 and O_2 be affected possibly to an extent that physiological damage can occur, but ethylene may also be produced, accelerating the process. In addition to possible physiological damage (often seen as grey pulp) fruit can arrive at the destination starting to soften, which decreases value due to short shelf life. Although shipment from Colombia to the USA is relatively short compared to destinations in Europe, taking only one to two weeks, delays in ports are possible, and therefore such hot spots in containers can still be a problem. For longer shipments, this is definitely an issue to be concerned about. Another issue if any warm fruit is loaded, is that the container may attempt to decrease the temperature to set point, resulting in excessive cold air and possible chilling damage.

Where possible, containers should be packed with fruit of similar maturity. This is particularly important early in the season or at points where maturity has reached a level where a decrease in shipping temperature is required. Pallets of less mature fruit have a higher risk of chilling damage. Such maturity differences are often related to fruit size, and therefore certain counts may have a higher risk. The same is noted for fruit of low calcium or high nitrogen (see section 1 on pre harvest production conditions).

The temperature is not the same throughout the container. The temperature at the air delivery end tends to be slightly lower than at the door end. Therefore, if it is necessary to pack pallets of known high risk for chilling damage, it is best to load these pallets closer to the door end than the air delivery end of the container. If necessary, some temperature compromise can be made, using a set point of slightly higher temperature, and in addition loading the lower risk fruit closest to the air delivery.

It is necessary to load the pallets in accordance with the correct loading pattern, and then finally, making sure that the base of the last two pallets is sealed as well as the T bar on the floor of the container to ensure that cold air is directed through the pallets from the bottom upwards. If pallets are to be shipped with controlled atmosphere (CA) (see below) ensure that the plastic curtain at the door end of the pallets is properly attached. A loose or collapsed curtain is often found in containers which arrive with the CA conditions incorrect.

Ensure that a temperature tracking device is included in all shipments. Because of the differential temperatures between the front and back of a container, the choice of pallet in which to place the recorder may be important. Close to the centre of the container would be an average position.

Due to the relatively short shipping times from Colombia to most USA destinations it is not necessary to ship using CA conditions. If CA is not used, however, it is essential to set the container ventilation to allow fresh air into the container. This needs to be added to the check list on container protocols, because containers to be shipped to Europe, which may be packed at the same time as the USA containers, will require CA conditions, and will have the ventilation set to closed. It is easy to forget the USA containers need ventilation open if the procedure in not on the check list.

There may be certain situations where CA shipping to the USA could be used. If delays such as port delays in Colombia or the USA arrival port are expected, or customs and phytosanitary clearance is expected to take longer than normal, resulting in a total shipping time of 3 weeks or longer, the use of CA shipment is advised. If used, there are a number of CA choices available. There is presently no data available to indicate which is best for Colombian fruit. The most commonly used CA conditions are:

- 5% O_2 and 5% CO_2
- 4% O_2 and 6% CO_2

QUALITY MANAGEMENT

The overall responsibility for quality management should be linked to the packing plant. This is because the packing plant has links with the producer (or is operated by the producer), is responsible for shipping and the conditions such as temperature of shipping, and is aware of the final destination for the fruit through the relationships with the customers the fruit is being shipped to.

If this is the case, then the packing plant management should obtain information on each of the fields (own fields or other producer fields) in terms of tree condition, yield, nutrition, with particular emphasis on the fruit calcium and nitrogen levels, dry matter and any known quality history. This can be used to best match fruit with destination and final usage (fresh market, ready ripe, or food service). In addition to these aspects, the most suitable cooling and shipping temperature can also be decided. Sample boxes of each consignment should also be held and stored at the normal shipping temperature for at least the time estimated for the product to reach the market. The advantage of this is that the packing plant can check quality under controlled and managed conditions. Knowledge of the fruit quality potential in the market possibly even before the fruit arrives at final destination, allows the packing plant to make changes to the shipping program and if necessary warn customers or distributors so that action can be taken. Normally 1 box per consignment is used, but more can be used for consignments with known risk or early or late in the season when risk is higher. Having these samples can also help determine where in the supply chain problems may be occurring, and therefore lead to solutions.

Because the packing plant is in possession of detailed information on the fruit and risks for quality defects, the packing plant should set the protocol parameters, check points and the appropriate documentation to support these throughout the supply chain. In order to ensure the protocols necessary, such as temperatures, CA if used, ventilation settings on the containers, any specific storage instructions and any other required information is known throughout the supply chain, these can be included in the bill of lading. This makes them part of the carrier contract and therefore must be taken into account by handlers through the supply chain.

In order to ensure that these processes do take place and can be monitored and controlled, it is suggested that a quality management specialist at the packing plant takes responsibility for implementation and management.

ACTION ITEMS - PACKING PLANT

- Ensure complete packing plant is an insect exclusionary area in accordance with USA phytosanitary requirements
- Hold fruit in arrivals area for as short a time as possible. In accordance with USA phytosanitary protocols packing must be complete within 24 hours of harvest
- Keep arrivals area as cool as possible, preferably 10 to 15oC (50oF to 59oF). if possible humidify the area
- Check every section of pack line for possible fruit damage areas. Take special care at fruit dumping and the washing and drying sections
- To decrease chance of bruising ensure fruit sizing is correct for packing patterns • Determine fruit cooling, holding and shipping temperatures using knowledge of dry matter, field origin of fruit and fruit quality aspects e.g. fruit nitrogen and calcium concentrations as well as logistics and final destination of fruit
- Load pallets with similar box design into cooling tunnels
- Monitor cooling rates to ensure even cooling of all pallets both inside and outside of pallets. Ensure skin temperature does not go below target pulp temperature for as little time as possible.
- Humidify cooling tunnels to decrease fruit water loss during cooling
- Store fruit at appropriate temperature
- Ventilate cooling tunnels and fruit holding rooms regularly after checking CO2 and ethylene levels. It is advised to include ethylene removal equipment in holding rooms. Ethylene should never be higher than 0.1 ppm. Be careful of exhaust gasses from trucks at the loading dock

- Do not load pallets if not at correct temperature
- Load pallets using correct loading pattern and seal areas where air can move past pallets to ensure air movement through pallets
- Ensure container ventilation is set to vent if CA is not being used
- Include quality management instructions such as temperature conditions for each part of the logistics chain as part of bill of lading
- Manage fruit from field to destination using data from critical control points
- Take appropriate action where necessary to ensure fruit quality is as close to the desired quality as possible
- Ensure all sanitary protocols are strictly applied

ARRIVAL AND HANDLING AT FIRST DESTINATION

Colombian fruit destined to the USA is shipped to a number of ports on both the east and west coasts. Customs and phytosanitary clearance will be needed on arrival. This has the potential to create delays as well as break the cold chain. Little can be done concerning any delays in clearing the containers, but all efforts should be made to ensure that there is as little as possible break in the cold chain.

Once the container arrives at the first point of discharge, fruit should be unloaded as soon as possible, and moved into a store with a temperature as close to the shipping temperature as possible. It is important that fruit should not be allowed to increase in temperature, as there is a possibility that ripening will start. If temperature is then decreased, the possibility of internal disorders increases due to the physiology of ripening requiring an increasing amount of energy, which can not be provided if the temperature has been decreased.

This leads to the collapse of cell membranes and disorders such as grey pulp. If fungal pathogens are present, such as those causing anthracnose or stem end rot, an increase in temperature and the start of ripening can stimulate development of these pathogens, which may, until this point, be dormant. This will have considerable effects on quality later in the supply chain. It is also important that fruit not be stored at temperatures substantially below the shipping temperature, as chilling damage can occur. This is particularly important early in the shipping season for low dry matter less mature fruit.

ACTION ITEMS - ARRIVAL AND HANDLING AT FIRST DESTINATION

- Ensure the cold chain is maintained, or restored if broken, as soon as possible
- Unload at first point of discharge as soon as possible, and store at the same temperature as stated on bill of lading

TRANSPORT AFTER CONTAINER UNLOADING

There are many different options after fruit arrives at the first destination and the container is unloaded. The facility may be a re-packing facility, fruit may or may not be ripened or processed such as for food service, or the facility may be a holding point or distribution centre. If the facility is a distribution centre or a repacking facility and the fruit is to be transported in a non ripened state to the final point of sale or another distribution centre, the objective will be to maintain fruit quality and ensure the longest possible shelf life. In order to achieve this, the cold chain needs to be maintained as best possible. The most suitable temperature will be that on the original bill of lading and as used for shipment from Colombia. The exception will be if the fruit has undergone ripening, where the new storage temperature should be used (see section on fruit ripening).

As part of the maintenance of the cold chain, the truck needs to be cooled to the carrying temperature before loading. This should be checked and recorded by both the driver and the dispatcher responsible for loading. Pallets should be loaded in accordance with the first in last out principle, especially if there are multiple stops with fruit for more than one destination.

Avocado fruit should preferably not be transported with any other commodity unless the transport is to the final destination such as a retail store. The longer the transport distance, the more important this procedure becomes. In particular, avocados should not be shipped with ethylene producing products such as apples, peaches, nectarines, bananas, melons, kiwifruit, but the non climacteric citrus is safe.

Truck drivers should ensure that cooling units are not switched off, as temperature rise can occur very rapidly.

ACTION ITEMS - TRANSPORT AFTER CONTAINER UNLOADING

- Transport fruit at the shipping temperature as indicated on the bill of lading unless fruit has been ripened in which case use the ripened fruit storage temperature
- Maintain the cold chain as best possible
- Load pallets in accordance with the first in last out principle
- Preferably do not transport with any ethylene producing products

DISTRIBUTION CENTRES

Distribution centres are essentially storage for fruit before final shipment to retail stores or ripening centres. The same principle as previously outlined, applies. To ensure that shelf life is as long as possible and maintain quality including prevention of post harvest disease development, the cold chain needs to continue to be maintained. Fruit should not be stored with any other types of fruit that generate ethylene.

Trucks need to be offloaded and moved into cold rooms as fast as possible, and the temperature logs checked by both the truck driver and the person accepting the fruit. Any discrepancy with the advised temperature should be noted. The pulp temperature of fruit should be checked in at least 2 out of every 20 pallets. Information should be sent back to the original packing plant. From a quality management perspective, it would also be good at this stage to conduct an overall quality assessment of the fruit, where the fruit is evaluated for external appearance, including lenticel damage, chilling damage, overall grading and pathological development such as anthracnose and stem end rot. Fruit softness using a penetrometer should be used. A number of fruit should also be cut to check internal quality. The incidence of grey pulp, vascular browning, and any pathological disorders such as stem end rot and anthracnose should also be noted. If not previously removed, the temperature tracking device installed at the packing plant should be removed and the data downloaded. The file should be included in information sent to the original packing plant.

When storing the fruit, it is desirable that all the fruit from Colombia be placed in a manner that the pallets can be grouped together. If logistically possible, fruit from different origins should not be mixed such that mixed groups of fruit will be placed into ripening rooms or sent to a further destination together in a way that they will end up being treated together. This will be explained specifically under the section on ripening.

Because large amounts of fruit move through the cold rooms and loading areas of distribution centres, and commodities other than avocados will most likely also be present, it is of great importance that the areas be regularly checked for the presence of CO_2 and especially ethylene. Ethylene should be non-detectable but if detected, not more than 0.1 ppm. Regular venting of fresh air should also be undertaken to prevent a buildup of gasses, especially ethylene.

It is also important, especially in terms of ethylene, that no internal combustion engine equipment should be operated in or near cold rooms. Trucks delivering fruit or at the loading docks to be unloaded should not be running when the loading dock doors are opened, and sufficient time after truck engines are stopped should be allowed for gas emissions to disperse.

To maintain good sanitation, all cold rooms should be cleaned on a regular basis with a sanitizing agent.

To ensure appropriate handling of avocado fruit, all operational staff at distribution centres should be adequately trained through the attendance of industry approved training, to fully understand the product and the handling requirements for the best possible retention of fruit quality.

ACTION ITEMS - DISTRIBUTION CENTRES

- Off load trucks as fast as possible to maintain the cold chain
- Store at temperature as close to shipping temperature as possible
- Do not store together with products that produce ethylene
- Preferably keep Colombian fruit as a group and try and not mix with fruit from other origins
- Check pulp temperature of fruit in at least 2 pallets per 20 pallets
- Find and down-load temperature data logger installed by the packing plant
- Check fruit quality concerning external disorders as well as a sample checking fruit softness and internal condition
- Send details of quality evaluation and fruit temperature to the original packing plant for quality management
- Check stores for gas build up and vent regularly
- Ensure all staff receive training on correct handling procedures

RE-PACKERS AND FRUIT RIPENERS

In some cases fruit will already be packed for retail such as in netting bags. However, most fruit will not, and if at a re-packer will need to be re-packed into a format required by retail customers. Fruit will then be dispatched to the final customers either in a green and hard unripe form, or in a ripened form. It is particularly in the ripened form that special note needs to be taken of the fact that the fruit originates in Colombia, as the ripening characteristics will be different to fruit from other origins, due to the different shipping and time since harvest conditions.

Before fruit is either dispatched to the final destination or ripening started, storage should be done in the same manner as outlined previously for distribution centres. Also, if fruit arrives directly from the port, the same procedures as previously outlined for first point of arrival and distribution centres should be undertaken.

UNRIPENED RE-PACED FRUIT

The intention for this type of fruit is to ensure that it reaches the final destination in an unripe condition with as long a shelf life as possible. Maintaining the correct temperature is the key to this. Use the shipping temperature decided upon by the original packing plant or as close to this as practical for storage until shipment to the final destination. This includes the time before re-packing and after re-packing and awaiting shipment to final destination.

During re-packing, the break in the cold chain should be as short as possible. In addition, the re-packing area should ideally be cooled to a temperature of approximately 12°C (53°F).

As with other storage areas such as at distribution centres, the storage areas at re-packing plants need to be regularly checked for the build-up of gasses such as CO_2 and particularly ethylene. This is particularly important in a re-packing plant where fruit is allowed to increase in temperature during re-packing, which could stimulate ethylene formation. The level of ethylene should preferably be undetectable, but if present at least lower than 0.1 ppm. The use of ethylene scrubbers is suggested together with regular venting of fresh air into the system. Depending on the volume of fruit moving through the system and the number of workers present, checking and venting should be carried out every 2 to 6 days.

RIPENED FRUIT

The procedures for handling and ripening fruit need to be carried out very carefully. The fruit becomes susceptible to damage from bruising, and if the procedures are not carried out at the correct temperatures and gas condition if using ethylene as a ripening agent, it is highly possible that serious quality defects will occur. More rapid development of fungal diseases such as those causing stem end rot and anthracnose are also possible if there is any fruit damage. This often only becomes evident at the final retail sales point, and severely impacts losses and customer perceptions.

It is intended that ripening be done on good quality hard, green fruit. The degree of ripening depends on final customer requirements, as well as time to final destination. However, fruit is never fully ripened before dispatch to the retail destination, unless the fruit is destined for further processing in a food service situation. This is because as the fruit softens, it becomes more susceptible to damage such as bruising. Such fruit creates a highly negative perception by consumers, and will damage sales and sales prices.

The best and most reliable way to ripen fruit is to trigger the ripening physiology using ethylene applied in properly constructed and controlled ripening rooms. However, the process will not be the same for all fruit, as the physiology is affected by the manner in which the fruit has been treated after harvest, as well as the pre harvest properties of the fruit due to field conditions, maturity and management. In the case of Colombian fruit, post harvest shipping time at low temperature to the USA is relatively short, but longer than other suppliers such as California and Mexico, but shorter than more distant suppliers. While most fruit will be shipped in normal atmosphere, some may be shipped using CA. Taking all these factors into account, this fruit will react to an ethylene stimulus for ripening at a different rate to other fruit in the market. Therefore, Colombian fruit should not be combined with fruit from other origins in ripening rooms. If fruit has been shipped with CA, it is necessary to leave the fruit in the storage room for 24 to 48 hours after arrival before starting the ripening process. The CA conditions are designed to suppress the ripening process, and it takes some time for this to reverse once the fruit is placed into normal atmosphere.

Fruit should only be moved out of the cold storage room immediately before ripening is to start. It is important to ripen fruit slowly, and therefore the temperature in the ripening rooms is critical. If temperatures are too high in an attempt to ripen faster, physiological disorders are potentially increased, as well as pathological disorders.The optimal ripening temperature is 18°C to 20°C (65°F to 68°F). Successful ripening including good colour development can be achieved at lower temperatures, but ripening room throughput will be affected.

Ripening is best achieved by using the addition of ethylene in the ripening chambers. Automatic ethylene control systems are the best choice to controlling the level of ethylene in the rooms. Ethylene can be applied as a trickle system and holding the concentration at 10 ppm ethylene. If this system is not used and ethylene is applied as an intermittent single shot process, ethylene is added to achieve a concentration of approximately 100 ppm. The concentration is then allowed to decrease over 6 to 8 hours.

During the ripening, it is essential that the room also be vented after approximately 8 hours to prevent a build-up of CO_2. The CO_2 concentration should not exceed 2% and preferably not 1%. High CO2 levels will prevent normal ripening from taking place, and there is a high possibility of grey pulp development.

The relative humidity of the ripening rooms should remain high, at 90 to 95% to prevent fruit dehydration.

The treatment time will vary with fruit maturity as well as the other factors outlinedabove. Approximate treatment times are as follows:

- Dry matter <23% use 2 to 3 days
- Dry matter 23-26% use 1 to 2 days
- Dry matter >26% use 1 day

It should be noted that the treatments are designed to initiate ripening and not to extend to the point of ripe or soft fruit. Fruit that is too soft will be more likely to be damaged by bruising as well as having a shelf life possibly too short for retail sale. The only exception is where the fruit is being ripened for processing. Fruit should be checked for ripening progress multiple times per day, and the process stopped when the fruit reaches the sprung stage where the fruit neck is slightly soft.

Once fruit has reached this stage it should be transferred to the cold room to re-cool as fast as possible, to 5°C to 6.5°C (41°F to 44°F) until the fruit is despatched to the final retailer.

If fruit is to be packed for final sale in packaging other than the original packaging used for shipping, care needs to be taken to ensure fruit is not damaged by bruising. If possible, it is also desirable to label the fruit as ethylene conditioned, so that in-store workers are made aware that the fruit needs to be treated differently for sale in terms of shelf life and display than non ripened fruit. If possible, a ready to eat date should also be applied as this will help both store managers and consumers to use the fruit at the best stage for optimum eating quality.

ACTION ITEMS - RE-PACKERS AND FRUIT RIPENERS

- Check arrival temperature and quality analysis and send data to original packing plant
- Place fruit in cold store at original shipping temperature and ensure as little break in cold chain as possible
- Do not store with any products that produce ethylene
- Store shipment as a group of pallets with other fruit from Colombia to make it easier to perform ripening or re-packing on similar fruits
- Re-packing areas should preferably be cooled to 12°C (53°F)
- After re-packing return to store at shipping temperature
- If fruit is to be ripened do not combine in ripening chambers with fruit from any other origin
- During ripening use temperatures of 18°C to 20°C (65°F to 68°F)
- Use high relative humidity to prevent dehydration
- Apply trickle ethylene maintaining 10 ppm or use intermittent shot dosage of 100 ppm renewing after 8 hours and check ripening progress regularly
- Vent rooms to prevent CO_2 build-up. Do not exceed 2% CO_2 and preferably not 1%
- Stop the process at the desired ripening stage (normally the sprung stage)
- Re-cool fruit to 5°C to 6.5°C (41°F to 44°F) and store until dispatchthis stage it should be transferred to the cold room to re-cool as fast as possible, to 5°C to 6.5°C (41°F to 44°F) until dispatch

SECTION 8

RETAIL SALES

The retail sales point is often the least controlled section of the logistics chain, and has a high potential for fruit damage and quality loss. The same care as taken during other stages of the logistics chain should be taken in transporting fruit from the last distribution centre to the store. Ideally, this should be temperature controlled, but this may not always be possible. Nevertheless avocados should be treated as a perishable product, and operators should not be deceived by the hard green state of the fruit for unripened fruit. Considerable bruising can occur due to poor handling, and for both hard green fruit and partly ripened fruit considerable shelf life can be lost by poor temperature management. Once the fruit reaches the retail store, the fruit should be placed in a cold room, until ready for display in the store.

Once in store, avocado fruit should be treated as a perishable product. There are certain key issues to maintaining good product quality:

Storage before display: Store fruit at low temperature, where possible at the temperature on the manifest, and wherever possible in a cold room without ethylene producing products such as apples. Control the inventory to ensure a rapid turnover of stock.

Inventory control in displays: Unripe avocado fruit have a shelf life of 4 to 7 days at store temperature. It is essential to move stock within this time, as a mix of ripe (especially over-ripe) and unripe fruit is certain to result in many fruits being in the display beyond their acceptable shelf life with resulting poor quality.

Fruit displays: This is a critical area for the potential of fruit damage and quality loss. As fruit soften, they will bruise easily, resulting in internal damage. In addition, post harvest diseases such as anthracnose, will develop faster, if present, causing fruit body rots. Over-ripe fruits in the display increase the risk of fruit damage. As fruit quality deteriorates, so consumer resistance rises and sales decline, affecting turnover and price for all avocado fruit. The major issues resulting in fruit damage in a display setting are:

- Fruit stacked too high, with lower fruit becoming damaged, especially once soft
- Large stacks of fruit with a mix of ripe and unripe fruit. The ripe fruit can become over-ripe within the stack if not carefully sorted by store staff
- Consumers testing fruit for ripeness resulting in extensive bruising

Solutions to the problem are relatively simple, and relate to good product management taking the perishable nature of the fruit into account.

- When setting up a display, fruit can be left in the boxes they were originally shipped in if possible. If fruit are to be placed individually in the display, they need to be placed carefully, not tipped into the display area.

- The display should not have more than 2 layers of fruit. Fruit will become damaged as it ripens if there are too many layers, as well as consumers tending to sort through fruit looking for suitable ones, and in the process damaging fruit especially as they start to soften.

- Do not place too much fruit into a display. Consider the display size in relation to the amount of fruit that can reasonably be sold before it becomes too ripe (a few days).

- Store staff sort the fruit daily to ensure the ripest (normally darkest coloured) fruit is moved to a position the consumer will see first, and can easily reach. This means placing these fruit on top and towards the front of the display

- Manage the display by removing any over ripe or clearly damaged or decaying fruit. This is a very important aspect of managing the quality of fruit in a display.

- Separation of riper fruit into a ripe and ready section can be useful.

- Ripe and ready fruit, should preferably be displayed in chilled sections to prolong shelf life.

- Do not display next to ethylene generating fruits such as apples.

- It would be preferable to sort fruit into different groups depending on origin. This is most important at the overlap of different supplier seasons, because maturities and ripening times will be substantially different.

- Place consumer information and education displays with the fruit to enable and encourage consumers to select fruit without checking for ripeness and thus bruising it. It is particularly important that fruit with low dry matter early in the season, often does not colour extensively or as darkly as more mature fruit. Consumers should be assisted by being informed of this, so that fruit is not left until over-ripe.

- At check-out, train staff to try and ensure fruit is not packed under other heavy or bulky items which will result in damage which the consumer will later experience.

Information and education: Although avocado fruit are a fairly well known product, there remains a lack of knowledge as to how to handle the fruit. As the final store sales and home storage and use are the least controlled quality management areas, but are also known to be the zones of maximum quality loss, information and education of store personnel and to consumers is essential to good fruit handling. Store personnel need to be adequately trained to understand the product and therefore to take the correct handling actions. Clear, easy to read advice to consumers is recommended. This should include how to store fruit until ripe, and how to determine optimal ripeness, after fruit are purchased.

Store audits: Retail stores are the only portion of the distribution chain that does not seem to have any easily checked operational conditions. A number of large producers and marketers of avocados in the USA have expressed the opinion that this is a clear deficiency, especially as it is in this area that considerable damage to quality can occur. It is suggested that the Colombian industry investigate ways in which to connect with retail sales groups to assist them to handle the product in the best way possible to ensure quality. This can be done as a part of marketing.

ACTION ITEMS - RETAIL SALES

- Treat fruit as a perishable product and store at temperature on the shipping manifest
- Do not store with ethylene producing products such as apples
- Control inventory to ensure rapid turnover of stocks
- Displays should be loaded at maximum 2 fruit deep if displayed as single fruit.
- Preferably display fruit in the original box packaging
- Manage display to sort ripe and unripe fruit into separate groups and remove overripe fruit from the display
- Display ready ripe fruit in a chilled display section
- Display fruit from different origins separately
- Manage displays such that customers can choose fruit without excessive handling
- Provide customers with clear guidance for fruit selection and use
- Train staff to better understand the product
- Organize and conduct store audits with additional training if necessary

COLOMBIA AVOCADOS
Discover a New Avo World

1417 Cardinal Road,Orlando, Fl. 32803
+1 407.415.5752
info@AvocadosColombia.com
AvocadosColombia.com
GET SOCIAL :