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INFLUENCE OF BOX TYPE ON TABLE GRAPE COMMERCIAL STORAGE QUALITY PERFORMANCE – 2007 SEASON

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EXECUTIVE SUMMARY

- During harvesting and quality storage evaluation, we observed that micro perforated box liners (MPBL) tore off easily as they were designed to meet the UK market's requirement for display ready. Thus, the micro perforated box liner did not fulfill the objective of protecting grapes from weight loss as expected. A better quality MPBL source should be located.

- The type of box combined with the micro perforated box liner (MPBL) affected commercial sulfur dioxide (SO_2) fumigation because the box penetration and SO_2 concentration used was very high. This SO_2 damage was expressed as dry/silver color rachises.

- Under these cold storage conditions, it took 2.1-4.9 hours for the fruit packed using the 2.2% micro perforated liner in these box types to reach 7/8ths cooling. These cooling times should not interfere with standard commercial table grape postharvest operations.
- These results indicated that grapes packed in other box types than ESP, but using proper inner packaging and SO_2 management, have the potential to maintain quality during mid-long term storage.
- The type of box combined with the micro perforated box liner and SO_2 pad usually did not interfere with weekly commercial SO_2 fumigation, but there is the potential to over fumigate. This SO_2 damage was expressed as dry/silver rachis color which is easily confused with dehydration.
- If the ESP, RPC, or Wenco plastic boxes are used, a special adjustment in cold storage operation management should be done such as monitoring SO_2 and cooling operations to avoid gray mold problems and/or SO_2 damage following the UC sulfur dioxide fumigation protocol described in Bulletin 1932.

INTRODUCTION

Packaging materials and their use have a tremendous impact on table grape quality, storage potential and arrivals. The material can increase cooling times if it retards airflow through the box or prevents the air from having direct contact with the product (convection). The use of box type, paper wraps, padding material, cluster bags, and box liners increases condensations and cooling times, requires higher static pressures, and may cause uneven cooling throughout the pallets. Thus, their use should be considered carefully. For example, the use of box liners in California reduces grape water loss, but can increase cooling time and may reduce passive sulfur dioxide penetration to dangerous levels. A good illustration of the effect of box liner venting pattern on cooling time has been developed for kiwifruit (Wiley and Crisosto, 1999). In general, fast cooling occurred when fruit were exposed to high rates of cold airflow. However, static pressure had to be increased to maintain the same airflow and have uniform cooling when using box liners with less venting.

During our last two years of table grape packaging work, we concluded that the use of the 2.0-2.2% vented area box liner (macro or micro) is the best fit for the California grape industry. This liner does not interfere with cooling or SO_2 fumigations under California's standard storage conditions and maintains fresh grapes in your box. Also, based on that work, we recommend checking your cooling and SO_2 fumigation operations as a standard practice for California table grape handling according to the UC-SO_2 manual (Luvisi et al., 1999).

OBJECTIVE

As a continuation of our program to improve table grape packaging in California, during this season we conducted studies to determine the best type of box for short- and long-term storage based on postharvest quality performance after commercial cold storage and a simulated transportation period.

MATERIALS AND METHODS

Based on our previous year's work using a late red colored table grape, we concluded that the SO_2 pad (SP) combined with 2.2% venting area box liner (BL) was the best combination for long-term storage. We preferred the macro perforated box liner rather than the micro perforated because of its better performance during field packaging.

A late red seedless table grape was packed in four box types: Weyerhauser corrugated cardboard (6-down), modified Maxco corrugated cardboard (5-down), Wenco white plastic (6-down), RPC (6-down), and, Expandable Polystyrene (EPS) foam (6-down). Two full pallets were used for each type of box, and in most of these cases, grapes were packed using the SWCB cluster bag, 2.2% VA micro-perforated box liner (MPBL) and Uvas Quality

sulfur dioxide pads (SP) except for the Weyerhauser cardboard where Stretch Vent cluster bags (SVCB) were used instead of SWCB cluster bags and the Wenco treatment in which the 2.2% VA micro-perforated box liner (MPBL) and Uvas Quality sulfur dioxide pads were replaced by the 0.9% VA Smart Bag box liner.

Grapes were packed using a diaper under the Uvas Quality sulfur dioxide pads (SP) and a paper diaper in the bottom of the box but over the box liner and enclosed in a 2.2% micro perforated box liner (MPBL). During packaging operations, grape weight was measured in three boxes per treatment, and temperature recorders and 5DH dosimeter tubes were placed inside one box per treatment. Also, at that time, bombers (Botrytis inoculated berries) were placed inside cluster bags in three boxes per treatment (27 cluster bags). These three boxes per treatment were carefully labeled for further tracking and evaluations.

Grapes were transported to cold storage for initial warm SO_2 fumigation followed by a forced air cooling. After fumigation and cooling, temperature recorders and 5DH dosimeter tubes were recovered. Then, two high pallets were cold stored up to 6 weeks for further commercial postharvest evaluations.

During the first 6 weeks of cold storage, SO_2 penetration was measured by placing 5DH dosimeter tubes in the center box, three boxes down in each pallet per treatment. After the first 6 weeks, 12 (two tiers) previously labeled boxes were selected for postharvest quality evaluations and temperature data logger recorders were recovered for data evaluation. For each treatment, we evaluated grape weight loss, cooling rates, and SO_2 penetration during forced-air cooling (initial). Then, we also evaluated grape water loss, decay incidence, and SO_2 penetration during weekly fumigation (storage). Fruit quality was evaluated after 6 weeks cold storage at 32ºF and 90% RH and after a two week simulated transportation period at 36ºF and 85% RH. Rachis browning, dryness, general box appearance (cluster condition), decay incidence and bleaching were measured in our quality evaluations. This report covers grape quality after SO_2 fumigation, cooling, and 8 weeks of cold storage.

Measurements

Table 1. Box types and inner packaging used in this storage quality performance study.

Treatments	
1.	Weyerhauser corrugated cardboard, SW cluster bag (SWCB), MPBL
2.	Weyerhauser corrugated cardboard, Stretch Vent cluster bag (SVCB), MPBL
3.	Maxco corrugated cardboard, SWCB
4.	Wenco plastic, SWCB, MPBL
5.	Wenco plastic, SWCB, 0.9% Smart Bag
6.	RPC, SWCB, MPBL
7.	EPS, SWCB, MPBL

RESULTS

Rate of forced-air cooling

Under these cold storage forced air cooling operation conditions, it took 2.1-4.9 hours for the fruit packed using the 2.2% micro perforated box liner in different box types to reach 7/8ths cooling (Table 2). The slowest cooling times were determined on grapes packed using the Smart Bag (0.9%) and the Weyerhauser corrugated cardboard with the SVCB, and the calculated 7/8ths cooling time was 4.9 and 3.7 hours, respectively. The rate of cooling for the ESP, RPC, Weyerhauser corrugated cardboard with the SWCB and plastic Wenco boxes ranged from 3.3 to 3.7 hours. The fastest cooling rate (2.1 hours) was achieved using the modified Maxco corrugated cardboard, SWCB, MPBL.

Table 2. 7/8^{ths} cooling (hours) measured during commercial forced air cooling.

Box Type	Hours to reach 7/8th cooling time
Weyerhauser corrugated cardboard, SWCB, MPBL	3.4
Weyerhauser corrugated cardboard, SVCB, MPBL	3.7
Maxco cardboard corrugated, SWCB, MPBL	2.1
Wenco plastic, SWCB, MPBL	3.3
Wenco plastic, SWCB, Smart Bag	4.9
ESP, SWCB, MPBL	3.6

It is important to point out that these rates of cooling were fast when compared with standard California table grape operations and this may be explained by the high CFM per pounds used during this specific cooling operation. However, this represents a good comparison among these boxes under the specific conditions. Further work comparing cooling rates at different cooling conditions will be carried out.

Sulfur dioxide penetration

Sulfur dioxide (SO_2) penetration during the initial forced-air fumigation was "satisfactory" for all of the box types (Table 3).

Table 3. Sulfur dioxide penetration measured using 5DH dosimeters during cold storage (32°F and 90% RH) on fruit packed using different box types and different inner packaging.

Treatment	Initial	Week 1	Week 2	Week 3	Week 4	Week 5
Weyerhauser corrugated cardboard, SWCB, MPBL	445	600	600	387	337	312
Weyerhauser corrugated cardboard SVCB, MPBL	600	600	600	450	362	400
Maxco cardboard corrugated, SWCB, MPBL	600	600	600	350	400	87
Wenco plastic, SWCB, Smart Bag	600	600	600	600	600	387
RPC, SWCB, MPBL	500	600	600	400	300	200
ESP, SWCB, MPBL	567	600	600	400	437	250

In general, the 5DH dosimeters were "maxed-out" after the initial fumigation in all box types except grapes packed in the Weyerhauser corrugated cardboard (SWCB). During the first 2 weeks of cold storage, SO_2 penetration was above the recommended levels, reaching >600 CT (ppm-hour) detected with the 5DH dosimeters measured after the fumigation. During the last 3 weeks of measurements when SO_2 applications went down from 50 to 20 pounds, the CT (ppm-hour) values were still above the recommended >250 CTs to control mycelium spread. During the 3 and 4 week storage period, SO_2 penetration readings were low for the corrugated cardboard boxes compared with the other box types. For the last week, when SO_2 dosage was reduced from 50 pounds to 20 pounds, SO_2 penetration was still above the recommended levels for all of the box types, indicating that the grapes were over fumigated during this cold storage.

Box weight gain

The EPS, Wenco, and RPC boxes did not gain weight during harvest, cooling or the 6 week cold storage period (Table 4). For grapes packed in the corrugated cardboard boxes, much of the box weight gain (~0.30 lb) occurred during the initial harvest and forced air cooling period.

Table 4. Weight gain measured after forced air cooling and 6 weeks cold storage (32°F and 90% RH) in different box types and different inner packaging.

Box weight gain	1 week	6 weeks
Treatment	Box weight gain lb	Box weight gain lb
Weyerhauser corrugated cardboard, SWCB, MPBL	0.3	0.3
Weyerhauser corrugated cardboard, SVCB, MPBL	0.3	0.3
Maxco corrugated cardboard, SWCB, MPBL	0.2	0.3
Wenco plastic, SWCB, MPBL	0.0	0.0
Wenco plastic, SWCB, Smart Bag	0.0	0.0
RPC, SWCB, MPBL	0.0	0.0
ESP, SWCB, MPBL	0.0	0.0

Grape weight loss

Grapes packed in any of the corrugated cardboard boxes lost ~1.6-2.5% of their initial weight after forced air cooling. Later on during cold storage, weight losses were insignificant (Table 5). Grapes packed using the RPC, ESP and Wenco boxes lost very little weight after cooling. There were no significant differences in weight loss between grapes packed in RPC, ESP and Wenco boxes as all of those boxes lost very little weight. There were no significant differences in grape appearance between grapes packed in RPC, ESP, or Wenco boxes. This can be explained because of the low weight losses measured during this study. Unfortunately, because many of the micro perforated box liners tore off during handling

due to their poor material and/or purpose, the weight losses of grapes packed in corrugated cardboard boxes were higher than expected but not high enough to affect rachis quality after cold storage. This study should be repeated during the next season and probably weight losses will be even lower. Thus, the use of a box type other than corrugated cardboard boxes combined with the 2.2% micro perforated box liner was the most effective treatment for controlling grape weight loss during postharvest handling (harvesting-cold storage).

Table 5. Table grape weight loss during 6 weeks of cold storage (32°F and 90% RH) on grapes packed using different box types and different inner packaging.

Fruit weight loss	1 week	6 weeks
Treatment	Weight Loss %	Weight Loss %
Weyerhauser corrugated cardboard, SWCB, MPBL	2.5 b	2.5 b
Weyerhauser corrugated cardboard, SVCB, MPBL	2.5 b	2.8 b
Maxco corrugated cardboard, SWCB, MPBL	1.6 b	1.8 b
Wenco plastic, SWCB, Smart Bag	0.0 a	0.1 a
RPC, SWCB, MPBL	0.0 a	0.0 a
ESP, SWCB, MPBL	0.0 a	0.5 a

Table grape quality attributes measured after cold storage (32°F and 90% RH)

By 6 weeks of cold storage, there were no significant differences in rachis browning between box types (Table 6). In general, rachises looked very nice (1-2) with a few cap stems starting to show some browning. However, all treatments (except Smart bag) packed using the 2.2% VA micro perforated box liner had a high incidence of dry/silver rachises (80-100%) due to high SO_2 applications, but not to dehydration. At this evaluation time, inoculated grapes packed in Wenco plastic with the Smart Bag (0.9% VA) had the lowest dry stem score (60%). Botrytis incidence on inoculated grapes was high but varied significantly according to treatment. Grapes packed in the Weyerhauser corrugated cardboard boxes had higher decay incidence (5.1%) than grapes packed using the Maxco cardboard corrugated ESP, Wenco and ESP. High bleaching incidence (2.8-9.2%) was also observed in all treatments, especially on grapes packed in the Weyerhauser corrugated cardboard and ESP boxes. There were no significant differences in cluster condition among box types; it was "good" for non-inoculated grapes packed in the different box types.

Table 6. Table grape quality attributes after 6 weeks cold storage (32°F and 85% RH) on fruit packed using different box types and different inner packaging.

TREATMENT	Decay (%)	Bleaching (%)	Rachis Browning (1-4)[z]	Dry/silver color Rachises (%)	Cluster condition (1-4)[y]
Weyerhauser corrugated cardboard, SWCB, MPBL	5.1 a	6.5 a	1.3	100	1.9
Weyerhauser corrugated cardboard, SVCB, MPBL	3.5 a	9.2 a	1.0	100	2.0
Maxco corrugated cardboard, SWCB, MPBL	0.0 b	2.2 b	1.0	100	2.3
Wenco plastic, SWCB, MPBL	0.2 b	3.0 b	1.0	90	2.1
Wenco plastic, SWCB, Smart Bag	0.1 b	2.8 b	1.0	90	2.0
RPC, SWCB, MPBL	0.5 b	4.2 b	1.0	80	2.1
ESP, SWCB, MPBL	2.1 b	7.4 a	1.0	100	1.9

[z] Rachis browning score: 1 = healthy, 2 = slight browning of the cap stems, 3 = browning of the cap stems and lateral stems, and 4 = severe browning of the cap stems, lateral stems and main rachis.

[y] 1-excellent, 2-good, 3-fair, 4-poor.

Table grape quality attributes measured after simulated transportation conditions (35°F and 85% RH)

After simulated transportation, there were no significant differences on rachis browning between box types (Table 7). In general, rachises still looked very nice (~2.0) with many cap stems starting to show some browning. Unfortunately, all treatments had a high incidence of dry/silver rachises (100%) due to high SO_2 applications, but not to dehydration. At this time, grapes packed in the Wenco box with the Smart Bag also had all grapes showing dry/silver rachises which could suggest that high SO_2 production may have occurred during the simulated transportation period due to changes in condensation inside the Smart Bag. Crystal formation was easily observed inside the Smart Bag during cold storage and during the simulated transportation period. Bleaching was very high (38%) on grapes packed in the Wenco plastic box with the Smart Bag and the ESP box with the SWCB and MPBL (30%). Botrytis incidence on inoculated grapes varied according to treatments. Grapes packed in the Weyerhauser corrugated cardboard boxes (1.7%) and in Wenco plastic boxes with the Smart Bag (1.4%) had higher decay incidence than grapes packed in Maxco corrugated cardboard, Wenco plastic, RPC, and ESP boxes with the MPBL which had the lowest decay incidence (0.4-0.6%). In general, cluster condition was good for grapes packed in all types of boxes without considering bleaching problems. Thus, grapes packed using the ESP did not have better cluster condition than grapes packed using other box types with the proper inner packaging.

Table 7. Table grape quality attributes after 6 weeks commercial cold storage at 32°F and 90% RH plus 2 weeks simulated period at 36°F and 85% RH on fruit packed using different box types and different inner packaging.

TREATMENT	Decay (%)	Bleaching (%)	Rachis score (1-4)[z]	Dry/silver color Rachises (%)	Cluster condition (1-4)[y]
Weyerhauser corrugated cardboard, SWCB, MPBL	1.7 a	10.5 b	1.3	100	2.1
Weyerhauser corrugated cardboard, SVCB, MPBL	1.7 a	16.6 b	1.5	100	2.6
Maxco cardboard corrugated, SWCB, MPBL	0.4 b	2.6 b	2.0	100	2.8
Wenco plastic, SWCB, MPBL	0.4 b	7.4 b	1.6	100	1.8
Wenco plastic, SWCB, Smart Bag	1.4 a	36.8 a	1.0	100	2.5
RPC, SWCB, MPBL	0.6 b	17.3 b	1.5	100	1.9
ESP, SWCB, MPBL P	0.4 b	31.6 a	1.1	100	2.3

[z] Rachis browning score: 1 = healthy, 2 = slight browning of the cap stems, 3 = browning of the cap stems and lateral stems, and 4 = severe browning of the cap stems, lateral stems and main rachis.

[y] 1-excellent, 2-good, 3-fair, 4-poor.

CONCLUSIONS

- Under these cold storage conditions, it took ~2.1-4.9 hours for the fruit packed using the 2.2% micro perforated box liner in these box types to reach 7/8ths cooling. These cooling times should not interfere with standard commercial table grape postharvest operations.
- During harvesting and quality evaluations we observed that the micro perforated box liners tore off easily, especially in the Wenco plastic and RPC boxes because of micro perforated design and poor quality. Besides the low quality of these box liners, they were designed to meet the UK market's requirement for "display ready". Thus, the micro perforated box liner did not fulfill the objective of protecting grapes from weight loss as expected. A better quality MPBL source should be located.
- Sulfur dioxide (SO_2) penetration during the initial forced-air fumigation exceeded the amount recommended for all box types tested. Thus, initial SO_2 dosage should be reduced to avoid potential damage to the rachis and/or berries.
- The type of box combined with the micro perforated box liner and SO_2 pad usually did not interfere with weekly commercial SO_2 fumigation, but there is the potential to over fumigate. This SO_2 damage was expressed as dry/silver rachis color which is easily confused with dehydration.

- These results indicated that grapes packed in other box types than ESP, but using proper inner packaging and SO_2 management, have the potential to maintain quality during mid-long term storage.
- If the ESP, RPC, or Wenco plastic boxes are used, a special adjustment in cold storage operation management should be done such as monitoring SO_2 and cooling operations to avoid gray mold problems and/or SO_2 damage following the UC sulfur dioxide fumigation protocol described in Bulletin 1932.

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RESISTANCE MANAGEMENT – A NECESSITY IN FUNGICIDE USAGE

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Currently, in addition to the inorganic copper and sulfur materials, ten classes of fungicides are registered for preharvest use on peaches and nectarines in California: the pthalimides (e.g., captan); dithiocarbamates (e.g., ziram); dicarboximides (e.g. iprodione); isophthalonitriles (e.g., chlorothalonil); benzimidazoles (e.g., thiophanate-methyl); sterol biosynthesis inhibitors (SBIs; e.g., fenbuconazole, myclobutanil, propiconazole, tebuconazole); strobilurins (QoIs; e.g., azoxystrobin, trifloxystrobin, pyraclostrobin); hydroxyanilides (e.g., fenhexamid); anilinopyrimidines (e.g., cyprodinil, pyrimethanil); and carboxamides (e.g., boscalid, a component of the pre-mixture Pristine®). The first four classes each have a multi-site mode of action, whereas the latter six classes all have a single-site mode of action and thus, target a single site in a specific biochemical pathway of a target organism. Fungicide classes, also referred to as fungicide groups, are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (see http://www.frac.info/). New fungicides introduced in 2008 include two pre-mixtures: tebuconazole-trifloxystrobin (i.e., Adament®) and pyrimethanil-trifloxystrobin (i.e., Distinguish®). Still, several new fungicide classes with unique modes of action are being developed and will be registered in the near future. With an increasing arsenal of fungicides available, using the proper material for good disease control while also keeping the risk of fungicide resistance to a minimum is becoming more difficult and requires an increasing amount of knowledge on the modes of action (fungicide classes), spectrum of activity, efficacy, and best usage strategies.

Resistance development is much more likely against single-site mode of action than against multi-site mode of action materials. In addition to the benzimidazoles, resistance has developed in pathogens of stone fruit crops in California against several of the newer fungicide classes. Thus, in populations of *Alternaria* spp. and *Cladosporium carpophilum*, causing Alternaria leaf spot and scab of almond, respectively, resistance is now widespread against the strobilurin fungicides. In 2007, resistance in *Alternaria* spp. was also common against the carboxamides. In addition, in 2007 we also found for the first time isolates of the brown rot pathogen of stone fruits, *Monilinia fructicola*, that were resistant to the anilinopyrimidines. Furthermore, in other stone fruit growing areas of the country, this latter pathogen has already acquired extensive resistance against the SBI fungicides, a very important class for the management of several stone fruit diseases.

Except for the benzimidazoles, to date resistance is not widespread in fungal pathogens of peach and nectarine in California. Thus, this is a critical time to remember the principles of anti-resistance management that are aimed towards preventing the development and spread of resistance. Resistance development in the field is mainly a selection process where a low fraction of the pathogen population that is naturally resistant multiplies in the presence of the selecting agent, i.e., the fungicide. Because members of a particular fungicide class have the same mode of action, cross-resistance patterns generally follow modes of action making all members of a class ineffective once resistance has developed against this class. Resistance development is a complex process that depends on characteristics of the pathogen, the fungicide class, and also the host. As a general rule, the risk of resistance development is highest when the following conditions are met:

- A large amount of pathogen propagules is present (e.g., when fungicides are applied when disease is already present – improper timing, especially during conducive environments)
- A low rate of fungicides is applied (e.g., alternate-row applications, air applications that are done at full canopy, or applications at low off-label rates)
- The pathogen is repeatedly exposed to the same chemical class (e.g., when no rotations are being done).

Based on these principles, several anti-resistance strategies have been developed that should be part of an integrated disease management program. The most effective way to combat fungicide resistance is to mix or alternate fungicides with different modes of action (classes of fungicides). If possible, at least one rotational mix partner should be a multi-site material. Because several highly effective classes of fungicides are available for peach, each class should be limited ideally to one and no more than two applications per season in rotation program. The use of fungicide pre-mixtures can be a step in the right direction, but both mixture components should have activity against a particular pathogen, otherwise they will act like single-fungicides in the selection process.

Fungicides are most effective in reducing disease and the amount of pathogen survivors when the environment is less favorable for pathogen infection and when disease pressure is lower. Consequently, planting, cultural, and orchard sanitation practices can be important components in an anti-resistance program. Disease pressure can also be lowered if a management program is started with multi-site mode of action fungicides. This practice will reduce the pathogen population size that is exposed to subsequent treatments with single-site mode of action compounds and the probability of selecting for resistance is reduced. A single-site mode of action fungicide should ***never*** be applied by itself when disease incidence in the orchard is already high.

The following "**RULES**" are a guideline for following fungicide stewardship:

- **R**otate or mix fungicides of different mode of actions. Suggested disease management programs with fungicide groups can be found at http://www.ipm.ucdavis.edu/.
- **U**se labeled rates – for strobilurins, use upper label rates.
- **L**imit the total number of applications of any single-site mode of action fungicide class to ideally one and no more than two per orchard per season in rotation program.
- **E**ducate yourself about fungicide activity, mode of action, and class – as well as resistance management practices. Visit the UC IPM website (http://www.ipm.ucdavis.edu/) to obtain this information.
- **S**tart a fungicide program with multi-site mode of action materials (e.g., Captan, Bravo/Echo, Ziram, Rovral, Sulfur).

Lastly, because fungicide resistance management has to be a large-scale effort due to the general free movement of air-borne pathogen propagules among orchards, it should be taken seriously by everyone.

NEW KIWIFRUIT DRY WEIGHT PROTOCOL

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Kiwifruit Sampling Protocol

Preliminary Field Sampling

1. Three healthy vines across the vineyard will be chosen for dry weight (DW) sampling.
2. Facing the trellis with the trunk of the vine as the center, the vine is divided into five equal sections: two to the left of center (upper and lower), the center and two to the right of center (upper and lower).
3. Six fruits are picked, from one side of the vine to the other, in each section on each of the three vines (30 per vine).

Preliminary Box Sampling

1. Five boxes from the largest and smallest fruit size of the lot will be selected across the lot for dry weight (DW) evaluations.
2. Three fruit from each box-size will be used for DW determinations.

Materials

Picture 1. Dehydrator: Nesco/American Harvest Snackmaster® Pro Food Dehydrator Product No. FD-50 http://nesco.com ($59.95). Automatic timer: GE 7-day home Security Timer DESC.: GE5112N-71M4SP Kmart ($7.99). 6 Outlet Metal Surge Protector: Power Sentry or comparable, Walmart ($12.77).

Picture 2. Balance, comparable to Denver Instruments Model MXX-212 with a capacity of 210 g, readability of 0.01g, taring range of 0-210 g. If purchased from Fisher Scientific includes operations manual and power supply and calibration weight, cat. No. 01-915-02 ($315.40).

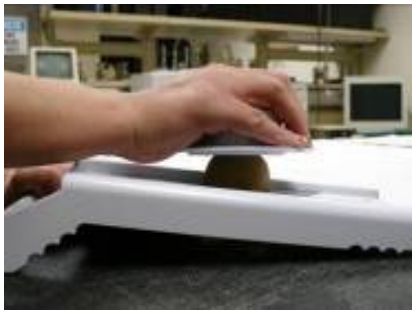
Picture 3. Multi Slicer: Progressive 6 piece Mandolin Multi Slicer #HG50 Progressive.com, Marshall's, Amazon.com ($10.99).

Table 1. Information on materials necessary to measure kiwifruit dry weight (DW).

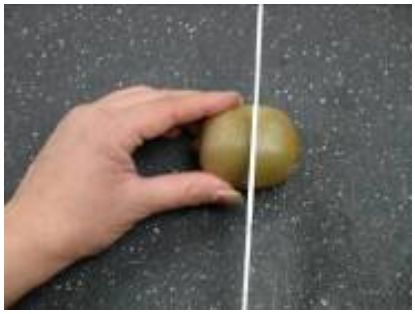
Material	**Place – Price**	**Special Specifications**
Dehydrator	http://nesco.com – $59.95	Nesco Product # FD-50
Automatic Timer	Kmart – $7.99	GE5112N-71M4SP
6 Outlet Surge Protector	Walmart – $12.77	Any comparable
Multi Slicer	Progressive.com – $10.99	Progressive Product No. HG50
Balance	Fishersci.com – Cat. No. 01-915-02 ($315.40)	Denver Instruments Model MXX-212, capacity 210 g, readability 0.01 g, taring range 0-210. Be sure the balance includes the power supply.
6" Sharp Knife	Any	
Clip Board	Any	
Cutting board	Any	
Thermometer	Free	carlos@uckac.edu

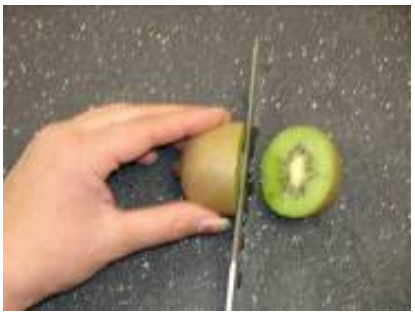
Drying Process Procedure

a. The dehydration process should take place in a secure and clean area such as a kitchen or small quality control laboratory.

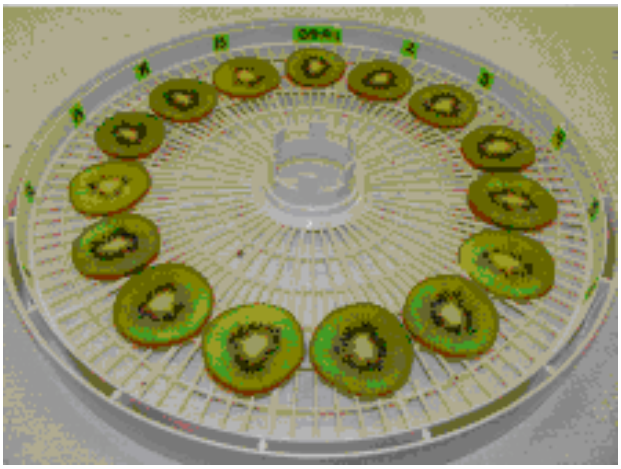


b. Take the 15 kiwifruit samples (without peeling them) and cut off 2/3 of the kiwifruit perpendicular to its long axis by using a sharp knife, then use the vegetable slicer to cut off a 1/8" thick slice from the center of the fruit.





c. Identify and label lot sample (column 1 in data sheet). As each dehydrator has three turntables and each can hold 15 samples at a time, we recommend, using each turntable level for each lot sample (15 kiwis) to avoid potential sample confusion. Thus, we can run three lots per each 10 hour per dehydrator.



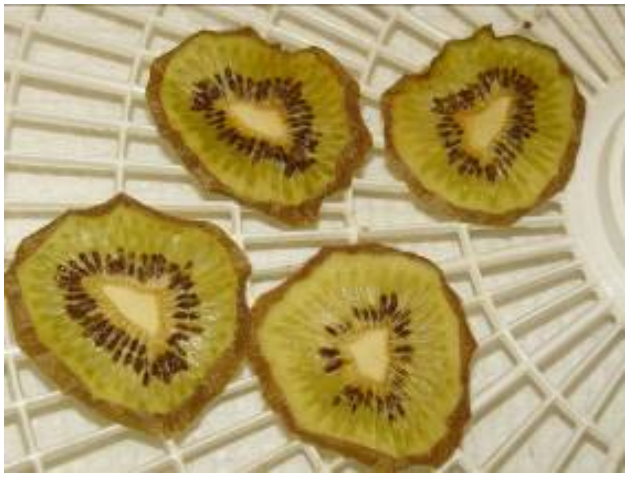
d. Within each turntable, assign a number to each slice to correspond with the position in the dehydrator (column 2 in data sheet). As each dehydrator has three turntables and each can hold 15 samples at a time, we recommend using each turntable level for lot sample (15 fruit) to avoid potential sample confusion. We suggest always working clockwise from turntable label to avoid confusion.

e. Weigh each slice and record the initial weight (g), to the nearest hundredths, and dehydrator position number.

f. When all of the sample slices have been placed in the dehydrator, turn on the automatic timer on the dehydrator for approximately 8 hours and 45 minutes.

g. After 8 hours and 45 minutes, reweigh each slice and record the final weight on your data sheet. Place the slices carefully back in the same positions in the dehydrator.

h. Run dehydrator for two hours longer and check weight again and record it under the "check weight" column in your data sheet. Compare the weights between the last two columns on your data sheet. If the weight has not changed for each sample, the dehydration process is done. Be sure that burning does not occur anytime during the dehydration process. Be sure that air temperature does not increase higher than 160^{o}F (71^{o}C).



i. If samples are dehydrated overnight using an automatic timer for 8 hours and 45 minutes or if the dehydrator has been off for a while before you recorded DW, warm up the dehydrators for about 30 minutes before the slices are weighed (final weight). Then follow the steps from step F on the protocol.

Data Sheet Template

SAMPLE ID	DATE	POSITION IN TURNTABLE	FRESH SLICE WEIGHT (TIME:)	FIRST DRY SLICE WEIGHT (TIME:)	SECOND DRY SLICE WEIGHT (TIME:)
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
		11			
		12			
		13			
		14			
		15			
Average					
Standard Deviation					

We thank Barbara Windmiller, Waine Aalto, and John Fagundes for their comments on this protocol.

FUTURE DATES

Upcoming events are posted on the Postharvest Calendar at the ANR website at:
http://ucce.ucdavis.edu/calendar/calmain.cfm?calowner=5423&group=w5423&keyword=&ranger=3650&calcat=0&specific=&waste=yes

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