Measuring avocado fruit maturity by dry matter

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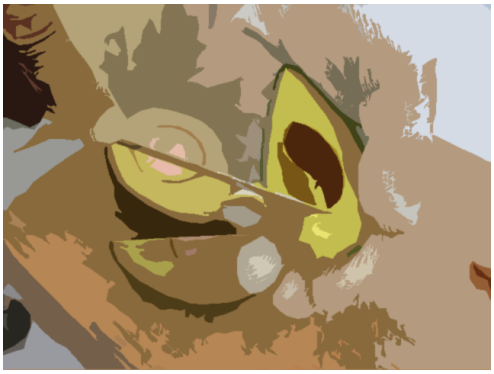
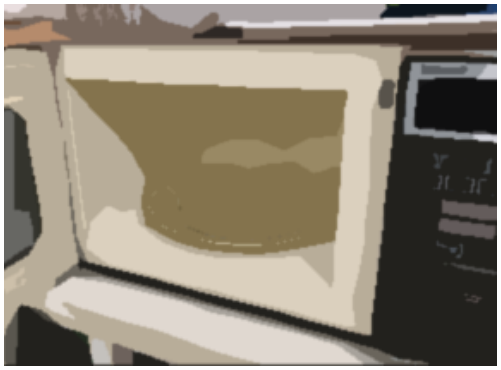
May 2023





1 Introduction

Avocado must meet minimum quality levels to meet consumer expectations and encourage return purchases. Avocado has to be harvested at the right stage, as maturity will not improve after picking. Therefore, it is essential that the fruit has reached the required marketing preferences before harvest.

For avocado, maturity is based on the measure of dry matter (DM) and is a standard tool used in all avocado producing countries. This ensures fruit are of good quality – both taste, and ripe-fruit quality. Research has shown a good relationship between dry matter content, fruit maturity and consumer preference. In addition, poor or low DM fruit result in poor ripe fruit quality and has significantly impacted on the reputation of the Kenyan avocado industry.

Here we provide a simple guide to dry matter testing and the recommended sampling points within the production chain to ensure best practice and fruit quality outturns. The guide is divided into four sections, as follows:

1) Recommended sampling points to monitoring maturity
2) How to sample tissue
3) How to dry tissue
4) How to calculate dry matter

As an example, the New Zealand avocado industry body has monitored the same five orchards every year in three regions for over nearly 20 years, and carries dry matter testing on an individual fruit basis to determine the spread of maturity. This involves up to 3 to 5,000 dry matter measurements and shows the industries commitment and the importance of this area. In addition, each orchard block must be "cleared" by sampling for DM analysis achieving average of 24%.

2 Recommended sampling points for monitoring maturity / DM along the production chain

2.1 Approving or "clearing" orchard near to harvest time (sampling from orchard)

Aim

While decision support tools (DST) or other monitoring gives a broad idea on DM levels, differences between individual growers – such as slope, aspect (north/south facing etc) can lead to DM differences. Thus it is important to verify that fruit from a orchard or nearby area are harvested at the minimum DM level.

Methodology

Frequency: Sampling should be done about 10 to 20 days before expected harvest to allow for tissue to be processed and dry, data to be examined, recommendations passed to growers and/or harvest teams and planning and logistics can be carried out.

Orchard selection: Select representative blocks from the orchard(s). The number of blocks will depend on the size of the orchard, topography (slope orientation – north / south etc), soil type and knowledge of historical differences in terms of maturity differences and/or harvest timing.

Trees: The trees should be selected to be representative of the trees in the block. If at all possible, the trees should not be at the end of rows, near the edge of the block, or in different soil types (e.g. old stream bed etc). Trees should be located in a diagonal across the block (i.e. from more than one row).

Fruit harvesting: Early in the morning (e.g. 9 am) sample 21 fruit from at least 7 trees. Fruit should be taken from around the trees (3 per tree). Fruit that should be sampled are those that are in the "main flush" or the one that is likely to be harvested (i.e. not very small fruit for example). Place fruit in a plastic bag for processing, keep out of direct sun and transport to the laboratory within a day of harvest. If possible, avoid sampling in days immediately after significant rainfall as this will tend to reduce DM.

2.2 Truck/incoming fruit to pack house

Aim

Another place that DM monitoring can be carried out is on incoming fruit (e.g. in trucks) that arrive destined for export or oil production. Verifying that fruit is not below maturity is an important step, and for avocado oil extraction, the DM level will predict potential oil yield.

Methods

The number of samples per truck will depend on the number of growers or the variety of harvest locations contained in the truck. The aim is to collect a representative sample from each "batch".

Randomly collect a sample of 21 fruit from the crates in the truck as they are unloaded. Depending on the number of crates, this could be one from each crate, or from every third crate (for example). Fruit should be taken randomly from the crate and should represent the average size of fruit in the crate.

3 Dry matter measurement

Hold fruit in the plastic bags in coolstore if fruit cannot be processed on the day of harvest, but process within 36 hours of harvest.

Measuring dry matter:

Tissue should be sampled from each of 21 fruit and combined (see below).

There are a range of ways of measuring dry matter, each with pros and cons. The key issues to balance are obtaining a representative sample from the fruit (which have LARGE variation in dry matter around the fruit), the time it takes to prepare samples, and staff safety. The methods below are well researched and accepted internationally.

3.1 How to sample tissue for DM

We present below the destructive measurement of DM which is the most robust way to measure DM. Non-destructive methods (for example NIR “guns”), are rapid, but the device is expensive (USD10,000) and less accurate.

On receiving fruit in the packhouse laboratory, weigh 21 fruit to obtain total weight (and thus obtain average fruit weight).

3.2 General methodology

A two decimal digital balance is recommended with connection to computer (saves time and data entry errors).

Label the pre-weighed dishes (these should be temperature resistant), and care taken as plastic trays (petri dishes) may melt in some drying systems.

Weighed tissue must be free of skin (peel) and seed coat tissue.

3.2.1 One fourth (¼) fruit “potato peeler” system

Equipment needed:

1. Kitchen potato or vegetable peeler
2. Small, sharp fruit knife
3. Fruit/vegetable dehydrator unit
4. Plastic Petri dish halves
5. Two-, or three-decimal place balance with data transfer cable

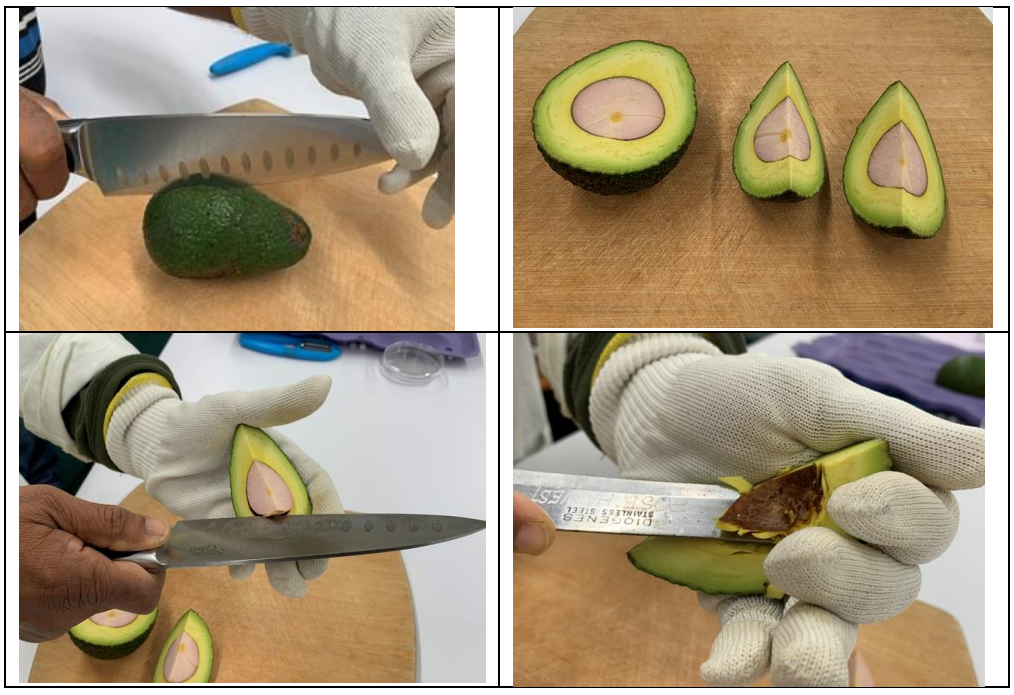


Figure 1. From top left; cutting the fruit longitudinally with a sharp knife; removing the seed; scraping out the seed coat; collecting thin slices of flesh from a halved avocado fruit after removing and discarding skin and stone; weighing fresh flesh after zeroing balance; samples ready for drying.

Figure 1 shows the steps in the procedure to determine the dry matter of avocado flesh samples.

1. Using a sharp knife or a guillotine cutter, cut the fruit longitudinally in half
2. Eliminate the stone and seed coat
3. Peel the fruit to remove the skin (NB: minimise the flesh removed)
4. Using the potato or vegetable peeler, remove thin slices of flesh from all around the cut
5. Zero (tare) the balance
6. Capture the weight of an empty Petri dish lid
7. Spread at least 100g of the shredded avocado evenly amongst the Petri dishes.
8. Capture the weight of the dish and fresh avocado tissue
9. Place the dishes in a systematic order using your preferred method of drying (refer to next section), and dry for a minimum of 24 h or until a constant weight is achieved. In the case of the use of a dehydrator, a maximum temperature of 65°C, is recommended.
10. Continue this process until all the fruit have been prepared
11. Once fruit processing has been completed, clean all the equipment

12. Preliminary investigations indicate that samples should have dried to constant weight after 24 h. This can be checked periodically during the season by comparing weights collected after 24, 26, and 28 h. The values should all agree to within less than 0.1 g. Capture the value of the dish and dried fruit.
13. Complete the DM calculation in the spreadsheet and transfer the file to another computer for backup and aggregation with Master record files.

3.2.2 Hoshi corer (or "Plugger") method

Equipment:

1. Hofshi avocado corer
2. Small, sharp fruit knife, or scalpel
3. Chopping board
4. Plastic Petri dish halves – use small Petri dishes where analysing single fruit samples, and large Petri dishes for bulk samples where there is more tissue
5. Two-, or three-decimal place balance with data transfer cable

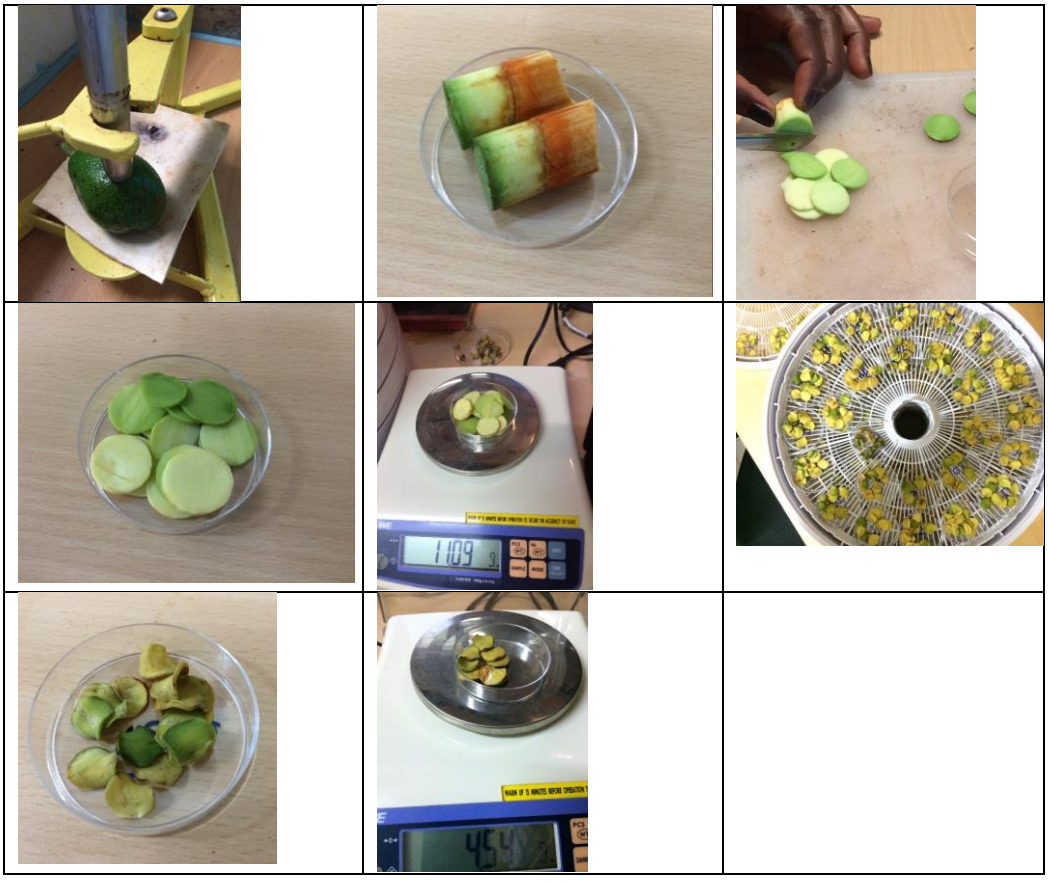


Figure 2: From top left; collecting a core cylinder using Hofshi corer; seed, flesh, skin core from a single fruit prior to dissection; slicing fruit flesh after removing and discarding skin and stone; dish of sliced fresh pulp from a single fruit; weighing fresh flesh after zeroing balance; a layer of dried flesh samples in the dehydrator; a dish of dried flesh slices; weighing the dish of dried slices.

Figure 2 shows the steps in the procedure to determine the dry matter of avocado flesh samples.

- Using the Hofshi corer, extract a cylinder of stone and flesh from each fruit (NB: Ensure the various nuts and screws on the corer (including on the top of the corer blade) are not loose as damage to the corer will result.)
- Carefully remove the skin and seed coat from the flesh on each side of the stone using a sharp knife keeping as much of the flesh as possible
- Zero (tare) the balance
- Capture the weight of an empty Petri dish lid
- Finely slice the plugs into thin sections (~1-2 mm thick to aid faster drying) and place into the weighed Petri dish
- Capture the weight of the dish and fresh avocado tissue
- Place the dishes in a systematic order in the dehydrator tray and dry for a minimum of 24 h at maximum temperature (assumed to be 65°C)
- Continue this process until all the fruit have been prepared
- Once fruit processing has been completed, clean all the equipment, particularly the Hofshi corer
- Preliminary investigations indicate that samples should have dried to constant weight after 24 h. This can be checked periodically during the season by comparing weights collected after 24, 26, and 28 h. The values should all agree to within less than 0.1 g. Capture the value of the dish and dried fruit
- Complete the DM calculation in the spreadsheet and transfer the file to another computer for backup and aggregation with Master record files.

3.3 How to dry sample tissue

There are a range of techniques that can be used to dry avocado tissue samples, but the key is to “dry tissue to a constant weight”. Key things to avoid are *not drying it completely* (which will give errors in dry matter figures), or burning the sample. Thus, temperatures of ≈ 65°C for 24 to 48 hours is generally recommended, although this will be influenced by the amount and thickness of the tissues, the ambient humidity and temperature, airflow of the dehydyrator etc.

To ensure tissue results are correct and repeatable, each system should be experimented with by the company/laboratory to determine the conditions / time needed to achieve a constant weight. This involves initially carrying out repeat weighing of samples to determine the time taken to achieve constant weight (no further decrease in weight). For dehydrators and ovens, this might be, say 3 times a day, while for microwave 1-2 minute intervals are likely needed.

Data should be typed (or directly downloaded by cable) immediately into a spreadsheet and the data checked to ensure results are sensible. Saving the tissue for a few days may be wise so that if problems or errors occur, tissue can be re-dried and reweighed.

Important note: Because dried tissue absorb water from the air (particularly in humid climates), fruit should be weighed immediately after removal from the drying oven or microwave.

3.3.1 Microwave drying

Use of a domestic microwave oven is one possible technique to dry avocado tissue (Figure 3). Because the ovens are readily available and the technique gives rapid results (within hours), this system might be preferred by some exporters / packhouses.

A standard amount of tissue should be used at each time to reduce the chance of burning of tissue, a low power setting should be used. As noted above, each microwave will be different and testing of the duration needed should be carried out until the time to achieve no further weight reduction. A container of water should be placed in the corner of the oven to stop tissue being burnt.

For example, because microwave ovens vary, it is critical to start at a low power setting and gradually work up to higher settings to prevent scorching. Suggested setting might be 40% power for 15 minutes. After weighing, microwave the sample again for 3 minutes at 40% power then reweigh. This process is repeated at one minute intervals until no further weight loss is observed (after several times of doing this, you can determine the proper power setting and approximate time). Avoid burning the sample.

Negative aspects of this system is the high amount of labour that is required, potential exposure of staff to microwaves (e.g. opening doors without waiting for 5 seconds), and possible user variability. It does however give rapid answers (a few hours). By comparison, a drying oven or domestic dehydrators will generally give results in 1-2 days with very minimal labour and also gives the ability to process many hundreds of samples.

Figure 3. A domestic microwave unit like this is one possible technique to dry avocado tissue.

3.3.2 Dehydrator

Domestic dehydrators are cost effective and readily available, cheap, and many dehydrators can be used at one time (Figure 4). These are used extensively for commercial systems in New Zealand with great reliability and minimal labour input. Petri dishes of avocado tissue is placed in the dehydrator trays which can be stacked up. One negative of this system is that layers at the bottom tend to dry faster than the top (air-flow is bottom to top). So care is needed to ensure variability is not a problem. Drying time is generally 1 to 2 days, and 2 days is very reliable.

Suitable brands include:

1. Ezidri brand (https://hydraflow.co.nz/product/ezidri-ultra-fd1000-digital-dehydrator/), available in South Africa through https://www.naturalwise.co.za/Ezidri-Ultra-dehydrator-FD1000- .

2. Similar units sold in Kenya - https://www.jumia.co.ke/mlp-food-dehydrator/; and https://www.whizz.co.ke/products/home-garden/small-appliances/specialty-appliances/dehydrators&skip=0&limit=24&brands=nutrichef/?page=1

Figure 4. Some examples of domestic fruit and vegetable dehydrators.

3.3.3 Drying oven

Drying ovens are more expensive, but have the capacity for many samples (on metal shelves), and the drying is even and more predictable (Figure 5).

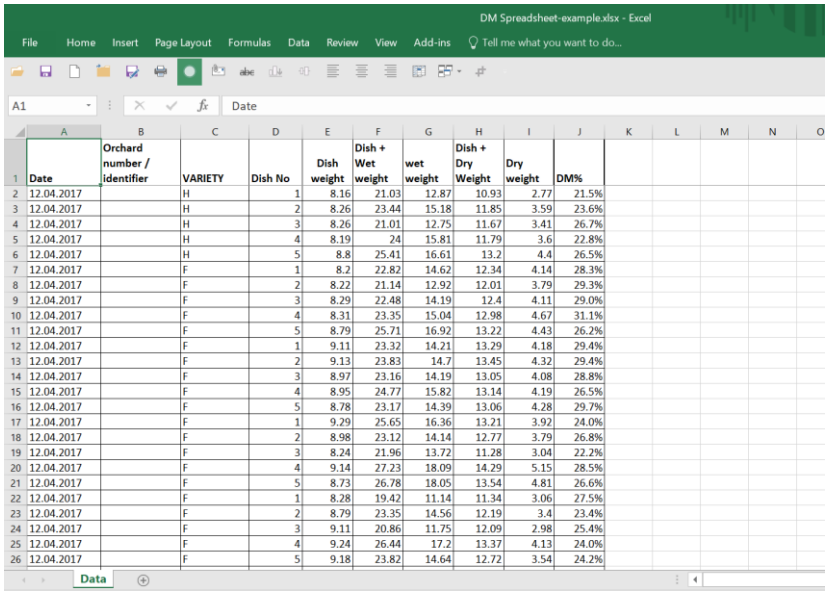
Figure 5. A drying oven like this offers even and more predictable drying.

3.4 Calculate percentage of dry matter

Use the following calculation:

$$\frac{\textit{Weight of dried avocado sample (minus weight of container)}}{\textit{Weight of fresh avocado sample (minus weight of container)}} \quad X\ 100$$

Data should be entered into a spreadsheet, and a cable system can be used to automate data input from the electronic balance to the spreadsheet (Figure 6).



Date	Orchard number / identifier	VARIETY	Dish No	Dish weight	Dish + Wet weight	wet weight	Dish + Dry Weight	Dry weight	DM%
12.04.2017		H	1	8.16	21.03	12.87	10.93	2.77	21.5%
12.04.2017		H	2	8.26	23.44	15.18	11.85	3.59	23.6%
12.04.2017		H	3	8.26	21.01	12.75	11.67	3.41	26.7%
12.04.2017		H	4	8.19	24	15.81	11.79	3.6	22.8%
12.04.2017		H	5	8.8	25.41	16.61	13.2	4.4	26.5%
12.04.2017		F	1	8.2	22.82	14.62	12.34	4.14	28.3%
12.04.2017		F	2	8.22	21.14	12.92	12.01	3.79	29.3%
12.04.2017		F	3	8.29	22.48	14.19	12.4	4.11	29.0%
12.04.2017		F	4	8.31	23.35	15.04	12.98	4.67	31.1%
12.04.2017		F	5	8.79	25.71	16.92	13.22	4.43	26.2%
12.04.2017		F	1	9.11	23.32	14.21	13.29	4.18	29.4%
12.04.2017		F	2	9.13	23.83	14.7	13.45	4.32	29.4%
12.04.2017		F	3	8.97	23.16	14.19	13.05	4.08	28.8%
12.04.2017		F	4	8.95	24.77	15.82	13.14	4.19	26.5%
12.04.2017		F	5	8.78	23.17	14.39	13.06	4.28	29.7%
12.04.2017		F	1	9.29	25.65	16.36	13.21	3.92	24.0%
12.04.2017		F	2	8.98	23.12	14.14	12.77	3.79	26.8%
12.04.2017		F	3	8.24	21.96	13.72	11.28	3.04	22.2%
12.04.2017		F	4	9.14	27.23	18.09	14.29	5.15	28.5%
12.04.2017		F	5	8.73	26.78	18.05	13.54	4.81	26.6%
12.04.2017		F	1	8.28	19.42	11.14	11.34	3.06	27.5%
12.04.2017		F	2	8.79	23.35	14.56	12.19	3.4	23.4%
12.04.2017		F	3	9.11	20.86	11.75	12.09	2.98	25.4%
12.04.2017		F	4	9.24	26.44	17.2	13.37	4.13	24.0%
12.04.2017		F	5	9.18	23.82	14.64	12.72	3.54	24.2%

Figure 6. A sample spreadsheet to allow for a more efficient and error free data inputting.

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