

## **MATURITY EVOLUTION OF ISABEL AVOCADO FRUITS (*Persea americana* Mill.), GRAFTED ON MEXICOLA STOCK**

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The Faculty of Agronomy of Pontificia Universidad Católica de Valparaíso has developed a new cultivar of Isabel avocado, with appealing characteristics for consumers. Fruits from the Isabel cultivar grafted on Mexicola rootstock were collected every 10 days, between April and October 2005, with dark green skin, in order to determine minimum oil percentage for commercial harvest. During every harvest period, part of the fruits were analyzed to determine percentage of oil, percentage of moisture and weight in order to establish the correlation curve between oil and dry matter. Subsequently, the rest was left to soften in anteroom (at room temperature) with up to 1.84 K of pulp resistance to pressure, determining: polar and equatorial diameter, pulp colour, skin and seed coat, fibrosity, seed-pulp relation, internal rot, skin blemish, loss of moisture and palatability, with the latter being assessed through a sensory evaluation panel. A correlation curve between variables of oil and moisture was determined:  $y = 89.0104 - 1.01018 x$  (percentage of moisture). The minimum percentage of oil determined for harvest was 12.81% (24.21% dry matter). The fruit has a high seed percentage (19.62%). A decrease of the softening period, loss of moisture and firmness of the fruits were reported in the season; whereas weight, equatorial and polar diameter did not show any variations; which means fruits reach their final size early in the season. Palatability increased as harvest time delayed.

**Key words:** oil percentage, dry matter, harvest, fibrosity, palatability, oil/moisture correlation.

## **EVOLUCIÓN DE LA MADUREZ DE FRUTOS DEL CULTIVAR ISABEL (*Persea americana* Mill.), INJERTADOS SOBRE PATRÓN MEXÍCOLA**

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La Facultad de Agronomía de la Pontificia Universidad Católica de Valparaíso, ha desarrollado un nuevo cultivar de palto "Isabel", con atractivas características para el consumidor. Frutos del cv. Isabel, injertados sobre patrón "Mxicola", fueron recolectados cada 10 días, entre abril y octubre del 2005, con color de epidermis verde oscuro, a fin de establecer el porcentaje mínimo de aceite para su cosecha comercial. En cada periodo de recolección, a una parte de los frutos, se les midió el porcentaje de aceite, porcentaje de humedad y peso. Esto para establecer la curva de correlación entre aceite y materia seca. Posteriormente, al otro grupo de frutos, se les dejó ablandar en antecámara (temperatura ambiente) hasta 1,84 k de resistencia de la pulpa a la presión, midiéndose: diámetro polar y

ecuatorial, color de pulpa, epidermis y testa de la semilla, fibrosidad, relación semilla pulpa, pudrición interna, defectos de epidermis, pérdida de humedad y palatabilidad, ésta última evaluada mediante panel de evaluación sensorial. Se determinó una curva de correlación entre las variables aceite y humedad de,  $y = 89,0104 - 1,01018 x$  (porcentaje de humedad). El porcentaje mínimo de aceite determinado para cosecha fue de 12.81% (24.21% materia seca). El fruto posee un porcentaje de semilla alto (19,62%). Se registró una disminución del periodo de ablandamiento, pérdida de humedad y firmeza de los frutos en la temporada, en cambio, el peso, diámetro ecuatorial y polar no tuvieron variaciones. La palatabilidad se incrementó a medida que se retrasaba la cosecha.

Palabras clave: porcentaje de aceite, materia seca, cosecha, fibrosidad, palatabilidad, correlación aceite/humedad.

## 1. Introduction

In the search of new varieties having characteristics appealing for the market and able to improve certain usual capabilities of the species, the Faculty of Agricultural Sciences from Pontificia Universidad Católica de Valparaíso has developed a new avocado cultivar named Isabel (Zúñiga, 1998). This cultivar, apparently a hybrid between Hass and Bacon cultivars, is characterized by having deep green-coloured fruits changing into black during their maturity, greater resistance to cold temperatures and by reaching a proper oil percentage for its export in a time shorter than Hass. It has a yellow pulp with yellowish green tones close to the skin. Its texture is quite soft and creamy with a light sweetness and its taste has been qualified as "pleasant" and very similar to Hass (Zúñiga, 1998).

The size of the fruit of the Isabel variety is medium to large, somewhat egg-shaped on its maturity stage; its average weight is 300 g; and the harvest season is long, starting at the end of July, a little earlier than Hass, and finishing at the end of January (Zúñiga, 1998).

In Chile, the rootstock mostly used in avocados is that coming from the seed of the Mexican strain, which in addition to granting some typical characteristics of the production, by coming from a seed, it also provides a high heterogeneity to production every year and forces to find alternatives for more stable productions such as stock (Castro *et al.*, 2003).

According to Kadman and Ben-Ya'acov (1976), there is also a clear effect of the rootstock on the oil percentage accumulated in the fruit. Every cultivar presents characteristic curves because of the differences among the increase rates of the oil content, as well as in the decrease rates of the moisture content. In addition, the avocado must have reached its physiological maturity at the moment of harvest in order to have a more acceptable palatability, so that it may reach its consumption maturity with good taste and quality (Olaeta and Undurraga, 1995).

Hofman *et al.* (2002) indicate that in the case of avocados, the oil content is nowadays the best indicator of maturity available.

The standard method to analyse the oil content is based on the Soxhlet method by extraction with petroleum ether. Nevertheless, the oil may be easily estimated through a single linear regression equation, which is practical, fast and not as sophisticated as the Soxhlet method (Lee, 1981). In Chile, this last method has been implemented in almost all the avocado cultivars available, having excellent results to forecast the moment of harvest of the avocado (Olaeta and Undurraga, 1995); however, it has not been corroborated for Isabel variety.

In the present trial, the minimum oil percentage was studied and determined as a harvest medium for Isabel variety, so that it assures an acceptable palatability during the consumption maturity.

## 2. Materials and methods

Grafted on Mexícola rootstock, 6 eight-year-old fruits of Isabel avocado tree, previously marked, were harvested at the Experimental Station La Palma of the Faculty of Agricultural Sciences, Pontificia Universidad Católica de Valparaíso, located in the city of Quillota (Latitude 32° 49' S, Longitude 71° 16'W).

The trees, with nearly 60 fruits, were divided into 3 groups, with each group of two trees forming one replication, where the treatments are the different harvest dates.

The avocados were randomly harvested every 10 days, between April and October 2005, with a dark green colouration of the skin, being processed at the Post-harvest Laboratory of the Faculty of Agricultural Sciences. During the first samplings, one fruit per replication was harvested (total of three), determining oil percentage (A.O.A.C, 1980) and moisture percentage (A.O.A.C, 1980) and also evaluating polar and equatorial diameter (manual Vernier caliper).

Then, with oil levels near 8%, four fruits per replication (total of 12) were collected; one to determine the oil percentage, moisture, diameter and three to quantify, after a softening period (ambient temperature) until reaching 1.84 k of pulp resistance to pressure (cone penetrometer 8 mm diameter), the following variables: weight (electronic balance PRECISA 3100C), colour of pulp, skin and coat in the seed (colorimeter MINOLTA CR-200; values expressed in CIElab modified by Mc Guire, 1992), weight loss (weight difference between harvest and consumption) and fibrosity, seed-pulp relation and internal rotting by visual observation. In addition, a sensory evaluation panel was formed, evaluating the following: taste, odour, texture, appearance and fibrosity, using the following rating scale: 0 (very unpleasant) and a maximum rate of 8 (very pleasant), determining the date on which each of these parameters reaches the best organoleptic level and that corresponds to the moment in which at least 80% of the panel had classified the samples into category 6 or a higher one (pleasant – very pleasant).

A simple regression analysis was conducted, between the independent variable X (moisture percentage) and the dependent variable Y (oil percentage). The Fischer test ( $p \leq 0.05$ ) was used to check the representativity of the model.

### 3. Results and discussion

Regarding the oil content, the existence of a progressive evolution of oil percentages through the sampling dates was demonstrated (Figure 1). This coincides with Martínez (1984), who mentions that as the fruit grows the oil content increases significantly, resulting in a curve characteristic for each cultivar. When comparing the oil evolution of Isabel variety with the curves obtained by Martínez (1984), Esteban (1994) and Saavedra (1995) in Hass variety, it is observed that the same pattern of oil accumulation; however, the Isabel variety reaches higher levels of oil in a shorter period since those obtained in Hass vary between 12 and 15% after December 31; in contrast the Isabel cultivar on September 21 reaches levels near 13%. Thus, fruit could be harvested before most black-skin varieties, entering the market earlier.

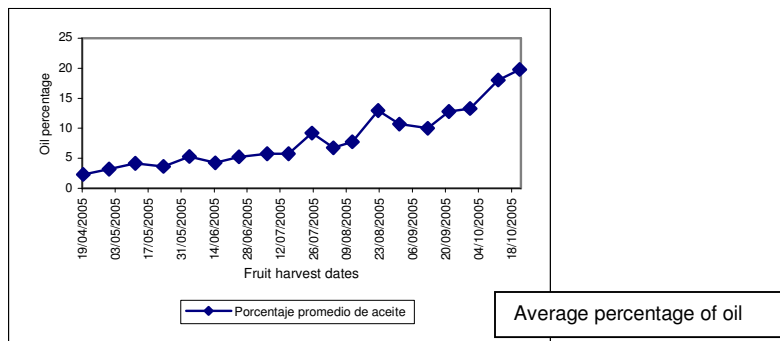


Figure 1: Seasonal evolution of oil percentage in fruits from Isabel avocado tree grafted on Mexícola rootstock.

The minimum and maximum oil percentages in Isabel variety, registered during the season, correspond to 2.29% on April 19 and 19.78% on October 21.

Regarding the variation of the moisture and dry matter content, there is a tendency towards reduction of moisture percentage as of the first week of August (Figure 2), and towards increase in the dry matter content, which is possibly produced by the fact that the maximum temperatures registered at the Experimental Station La Palma during the first two weeks of August reached an average of 20.7°C (69.26°F), while an average of 16°C (60.8°F) during the last two weeks of July. Kaiser *et al.* (1992) mention that the oil content may be also related to maximum temperatures of the orchard.

The maximum value of the dry matter percentage was obtained on October 21, an average of 29.73%, which corresponds to 70.27% of average moisture and

19.78% of oil. The mean minimum percentage of dry matter was 15.32% on April 30 with 81.06% of moisture and 3.25% of oil on average.

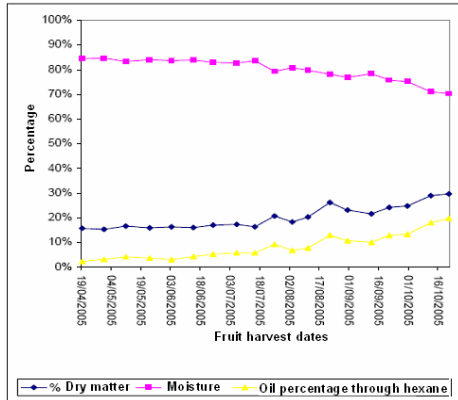


Figure 2: Seasonal variation of moisture, oil and dry matter percentages in fruits from Isabel avocado tree, grafted on Mexícola rootstock

For the regression analysis and correlation coefficients, the parameters of moisture and oil percentages were evaluated, determining that the moisture content is related in an inversely proportional way to the oil content (Figure 3). In this way, the following graphical correlation was established:

$$Y = 89.0104 - 1.01018 * X$$

Where:

Y: oil percentage

X: moisture percentage

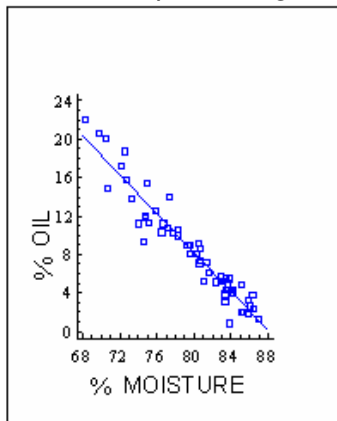


Figure 3: Regression curve between the percentage of oil and moisture in fruits from Isabel avocado tree, grafted on Mexícola rootstock.

The coefficient of determination calculated was  $R^2 = 91.9542$ .  $R^2$  indicates that the model interprets 91.9542% of the variability in Y.

The correlation coefficient calculated was  $R = -95.5893$ . This indicates that the correlation degree between the variables of oil and moisture is high and inverse.

Regarding the seasonal variation of size, the weight of fruits of Isabel variety remains almost constant during the season, presenting a variation between 250 and 300 g (Figure 4). This indicates that fruits reach their final size very early in the season, probably influenced by the size of the stone.

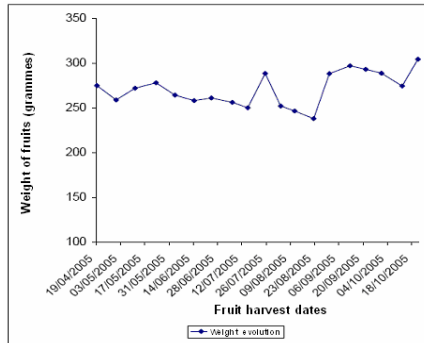


Figure 4: Weight evolution of the fruit from Isabel avocado tree, grafted on Mexícola rootstock.

The minimum and maximum polar diameter registered in this cultivar was 7 and 15.1 cm respectively, while the equatorial diameters varied between 5.8 and 7 cm, which results higher for Hass and Bacon varieties in the polar diameter and lower in the equatorial, compared to the data of Martinez (1984), who confers Bacon an equatorial diameter of up to 10 cm.

The date established as suitable to carry out the harvest in Isabel variety was September 21; on that date the fruit lost 5.57% of moisture (Figure 5). The results obtained by Martinez (1984), as Olaeta and Undurraga (1995) in Hass and Bacon varieties, based on the suitable date on which those varieties must be harvested until the consumption maturity, determine that the percentage of moisture loss for Hass and Bacon was 4.2% and 5%, respectively.

Luza (1992) suggests that the percentage of moisture loss must be above 10% to affect the fruit. In this way, the fruits of Isabel, Hass and Bacon varieties would not be affected in appearance for their commercialisation.

For the variable of pulp resistance to pressure, the maximum average value was determined to be registered on August 3 with a 6.73% of oil, with 3.17 and 3.25 K for the proximal and distal zone, respectively.

For the subsequent dates, the average values, in both distal and proximal zones, fluctuated between 1.38 and 2.3 K, obtaining a minimum average value of 1.38 K, on September 30, for each zone. The above-mentioned indicates that as the sampling dates go by and the oil contents increase, pulp consistency decreases (Figure 6). In this sense, Latorre (1994) and Saavedra (1995) mention that the avocado fruits present a decrease in the pulp consistency while the harvest dates pass.

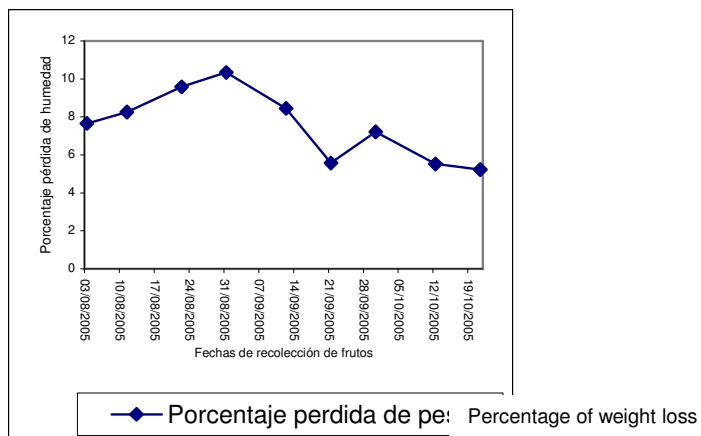


Figure 5: Percentage evolution of weight loss between the harvesting date and consumption maturity in fruits of Isabel avocado tree, grafted on Mexícola rootstock.

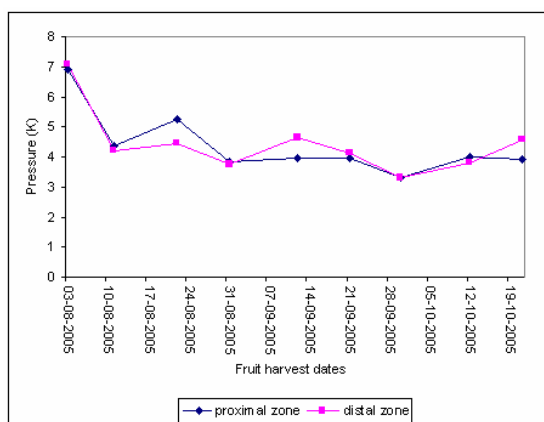


Figure 6: Evolution of pulp resistance to pressure (K) in the distal and proximal zones of Isabel avocados, in consumption maturity, during the harvest dates.

In regard to the curves obtained in the apical and distal zones of the fruit, no differences were noticed between them, with a very similar evolution pattern in both, which would indicate a homogeneous maturity, which is an attractive characteristic for its commercialisation.

Regarding the fibrosity, it was determined that during all the sampling dates, the Isabel avocado fruit does not present fibre in pulp; such characteristic is also noticed in Hass variety.

This attribute is appreciated and considered important for commercialisation, since consumers prefer the fruit with no fibre.

Regarding the seed / pulp relation, the size of seeds was determined to be large in comparison to the fruit, since the maximum seed/pulp relation is an average of 19.62% (Figure 7).

The above mentioned coincides with Zúñiga (1998), who describes a large seed compared to the fruit, representing between 15 and 20% of the total weight.

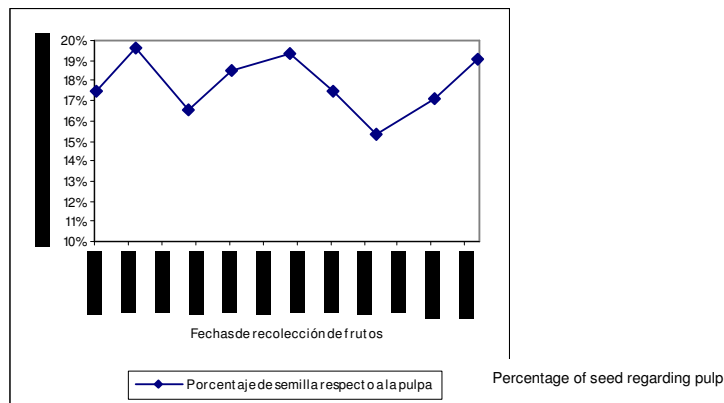


Figure 7: Seed/pulp relation during the growth of fruits from Isabel avocado tree grafted on Mexícola rootstock.

For the variable of pathological disorders, it was determined that between August 3 and 31, at least one replication per treatment showed symptoms of dark brown soft rot that jeopardised the pulp of the fruit from the periphery to the centre, situation that was not observed in subsequent samplings. In laboratory, *Fusicoccum* sp. was consistently detected. Its incidence in Isabel fruits during August could be caused by frequent rainfalls (total 89.5 mm) in such month, and by the fruit harvested without peduncle, condition suitable for fungi, which penetrate through injuries.

The colours of seed, pulp and skin have a very similar evolution pattern; as of August 21 (suitable moment for harvest), these three variables present a change of colour, turning to darker tonalities, which is increased at the consumption maturity. According to the above-mentioned, the skin colour, together with that of pulp, could be used as indicator of harvest in Isabel avocados. Lee (1981) states that a considerable change is produced in many types of fruits as maturity advances; therefore, the change in colour reflection or transmission may be used as indication of consumption maturity.

To establish the best harvest period, according to the sensory analysis, it was considered for each variable that above 80% of the panel had rated the samples in category 3 (pleasant – very pleasant). Subsequently, when having the proper date for each variable, a unique date was designated (Table 1). Therefore, combining the variables evaluated and the sensory panel, it could be determined that the minimum oil percentage to harvest the Isabel variety for an acceptable palatability is 12.81% of oil with 75.78% of moisture and 24.21% of dry matter.



Table 1: Summary table, in which each of the variables develops correctly towards maturity consumption in Isabel fruits grafted on Mexícola rootstock.

| <b>VARIABLE</b>     | <b>PROPER DATE</b> |
|---------------------|--------------------|
| Taste               | 21/9/2005          |
| Texture             | 21/9/2005          |
| Odour               | 30/9/2005          |
| Internal appearance | 12/9/2005          |
| External appearance | 31/8/2005          |
| Fibrosity           | 12/9/2005          |

#### 4. Conclusions

The graphical correlation between the variables of oil and moisture for the Isabel cultivar grafted on Mexícola is  $Y = 89.0104 - 1.01018 * X$ .

The minimum oil percentage to assure an acceptable palatability in Isabel fruit grafted on Mexícola is 12.8% of oil, 24.2% of dry matter and 75.7% of moisture.

The Isabel fruits grafted on Mexícola rootstock have a high seed / pulp relation, which is an unfavourable condition for its commercialisation.

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