Proceedings VI World Avocado Congress (Actas VI Congreso Mundial del Aguacate) 2007.
Viña Del Mar, Chile. 12 – 16 Nov. 2007. ISBN No 978-956-17-0413-8.

CORRELATION OF OIL CONTENT, DRY MATTER AND PULP MOISTURE AS HARVEST INDICATORS IN HASS AVOCADO FRUITS (*Persea americana* Mill) GROWN UNDER TWO CONDITIONS OF ORCHARDS IN CHINCHA-PERÚ.

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This work aimed at the determination of the correlation among oil content, dry matter and pulp moisture in avocado fruits (*Persea americana* Mill) var. Hass) grown in two locations: Alto Larán (La Calera farm) and El Carmen (Copacabana farm), both in Chincha-Perú. Harvest started 208 days after main flowering stage and lasted seven weeks. Results showed a positive correlation between oil content and dry matter content of pulp in fruits from in Alto Laran (r = 0.9583), which is shown by the regression equation y = 0.9908x – 10.43. In El Carmen the correlation was also positive (r = 0.9544) and its equation was y = 0.9754x – 10.32. The oil and pulp moisture content had an inverse correlation in Alto Laran (r = -0.9583) with a regression equation as y = -0.9908x + 88.65. In El Carmen the negative correlation (r = -0.9544) was explained through the regression equation y = -0.9754x + 87.22. The postharvest respiratory curve of the avocado fruits showed a typically climacteric response, obtaining the climacteric crisis 16 days after fruit harvested in Alto Laran and within 18 days in those harvested in El Carmen.

Key words: maturity indices, harvest, postharvest, correlation

CORRELACIÓN DEL CONTENIDO DE ACEITE, MATERIA SECA Y HUMEDAD DE PULPA COMO INDICADORES DE COSECHA EN FRUTOS DE PALTO (*Persea americana* Mill) VAR. HASS CULTIVADA BAJO CONDICIONES DE DOS LOCALIDADES EN CHINCHA-PERÚ.

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Se realizó un ensayo con el objetivo de determinar el grado de correlación entre el contenido de aceite, materia seca y humedad de pulpa en frutos de palta (*Persea americana* Mill) var. Hass cultivada en dos localidades, Alto Larán (predio La Calera) y El Carmen (predio Copacabana) ubicados en Chincha-Perú. La cosecha de los frutos se inicio a los 208 días después de cuajada la floración principal. La recolección de frutos se realizó durante siete semanas

consecutivas. Los resultados muestran una correlación positiva entre el contenido de aceite y el de materia seca de la pulpa en los frutos provenientes de la localidad Alto Larán (r = 0.9583), la cual se interpreta a través de la ecuación de regresión: y = 0.9908x – 10.43; mientras que para los frutos provenientes de la localidad El Carmen la correlación positiva (r = 0.9544) se interpreta mediante la ecuación: y = 0.9754x – 10.32. El contenido de aceite y humedad de pulpa mostraron una correlación inversa en la localidad Alto Larán (r = -0.9583), y una ecuación de regresión de: y = -0.9908x + 88.65, mientras que en la localidad de El Carmen la correlación inversa (r = -0.9544) se interpretó a través de la ecuación: y = -0.9754x + 87.22. El ritmo respiratorio poscosecha de los frutos mostró un comportamiento típicamente climatérico, obteniéndose a los 16 días el instante de crisis climatérica en aquellos frutos provenientes de la localidad Alto Larán, y a los 18 días en los recolectados en la localidad de El Carmen.

Palabras claves: índices de madurez, recolección, poscosecha, correlación.

1. Introduction

The quality of the fruits is a combination of attributes which bring value to them as food. Therefore, it is very important to sustain these attributes by conducting a timely harvest at the optimum moment (Kader, 1992; Pantastico, 1985). In the case of avocado, the time of harvest is very important to obtain a satisfactory storage (Cajuste, 1992; Parodi and Lerner, 1995). Generally, it is difficult to determine visually when an avocado fruit is ready to be picked off, due to the fact that it does not show notable changes in its external appearance (Lee, 1981; Lewis, 1978; Pantastico, 1975). In reference to avocado harvest indicators, perhaps the most important of them is the determination of oil (INIA, 1997), due to the direct relation among the maturity grade of fruit and the oil accumulation and dry matter (Lee et al., 1983; Lewis, 1978). Nowadays, the oil content as well as the dry matter content are used in almost all the regions of the world that produce avocado, in order to determine a minimum maturity for the fruit (Parodi, 1996). These indicators are also applied in the Peruvian case, although there is not accurate information by valleys or zones regarding the minimum level of oil that fruits require to start the harvest (Parodi, 1998). Usually, the Peruvian central coast valleys start the Hass avocado harvest with minimum oil content of 8 -9 % and dry matter content of 20-21% (Franciosi, 2003). Nevertheless, since there is a lack of accurate data, it was suggested that values could be higher than the abovementioned (Parodi 1996). The objective of this work was to research about Hass avocado fruits cultivated in two locations of Chincha in order to determine not only the correlation degree of oil content with dry matter and with pulp moisture for Hass, but also the variation in these parameters during the period of harvest.

2. Materials and Methods

The test considers two locations: Alto Larán (Fundo La Calera at 201 m.a.s) and El Carmen (Fundo Copacabana at 102 m.a.s), both situated in Chincha-Ica.

Just after set fruit, a total of 308 fruits resulting from the main flowering of August-September were marked in each location. The harvest started 208 days after set fruit (asf) is over, and 44 fruits were picked off once a week during 7 weeks in each location. These fruits were placed in a preconditioned environment with a temperature which fluctuated between 20 and 24ºC, in order to obtain its postharvest natural ripening. There were obtained 4 repetitions of 2 fruits from the 44 harvested fruits, which were used to estimate the harvest indicators. The remaining 36 fruits were distributed in 9 samples composed by 2 repetitions of 2 fruits, which were used to determine the respiratory rhythm. The model of simple linear correlation, which was applied as statistical test for the experimental work, determined the relationships between oil content and dry matter and between oil content and pulp moisture and obtained the association intensity using the correlation coefficient. During the test period, the statistic analysis of changes in harvest indicators was developed by one-way ANOVA with a CDR arrangement that considered 7 treatments, where each week was assumed as a treatment composed by 4 repetitions. Likewise, a Tukey's Mean Separation Test was performed with a significance level of 1%. The evaluations performed were:

Respiration intensity: Expressed as ml CO_2 kg-hr^{-1} liberated by the avocado fruits inside a hermetically -sealed glass container. A MOCON gas analyzer was applied during the test.
Dry matter and pulp moisture: Obtained by weight difference of 50 grams of fruit pulp placed in a MEMMRET oven at 70ºC during 48 hours.
Oil content: Obtained by the method of extraction that employs a Soxhlet-distiller. The official USDA procedure for determination the oil content of vegetable organs was followed employing petroleum ether as solvent (Lee, 1981).

3. Results and Discussion

Correlation between oil concentration versus dry matter and pulp moisturet:

The obtained results in terms of oil content expressed as a function of dry matter content (Fig.1) showed a higher positive correlation; it means that, in the case of avocado fruits, the dry matter content increases as the oil content increases. Alto Larán showed a correlation coefficient (r) of 0.9583, while El Carmen obtained r = 0.9544. The high degree of correlation between these two components has been mentioned before by other researchers (Lee et al., 1983; Ranney, 1991). On the other hand, it was obtained a high inverse correlation between oil and moisture contents of avocado fruits (Fig. 2). It means that there is an increase of oil content with a reduction of the moisture content. In this case, Alto Larán showed a correlation coefficient (r) of -0.9583, while El Carmen obtained r = - 0.9544. The relation degrees obtained between oil and dry matter contents or between oil content and percentage of pulp moisture are interesting due to the fact that oil percentage in avocado fruits results feasible to estimate by these two components. In this case, there is the possibility to estimate oil content using as references the dry matter or the moisture content and applying

the equations resulted of a simple linear regression, which are practical and easy to follow (Lee, 1981).

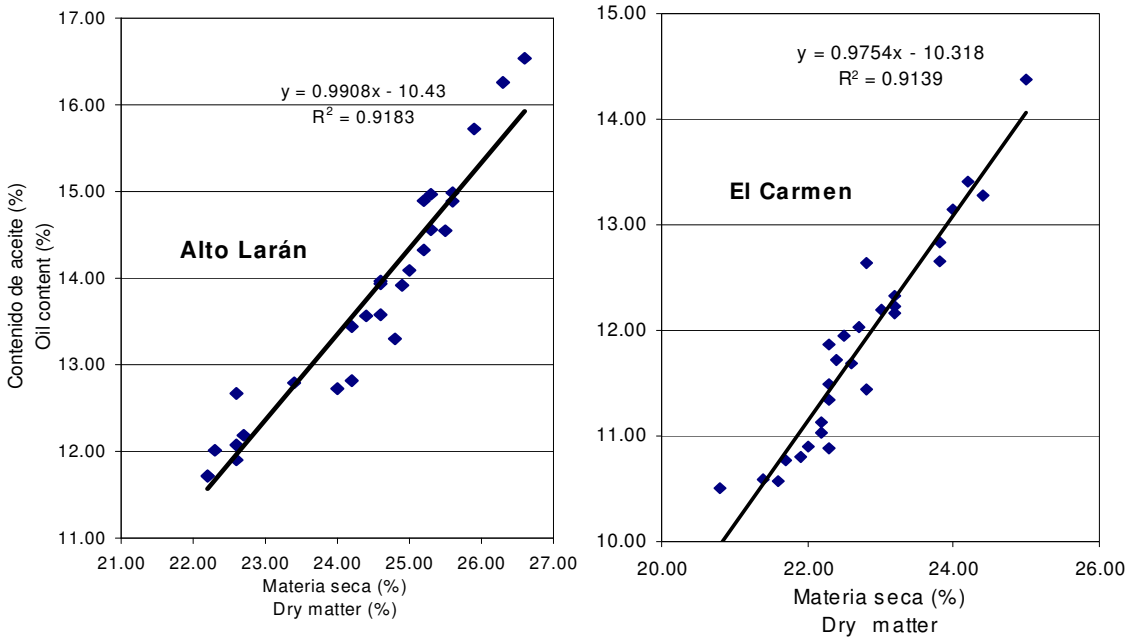

Figure 1: Oil content in avocado fruits (*Persea americana* Mill) var. Hass in function of the dry matter content.

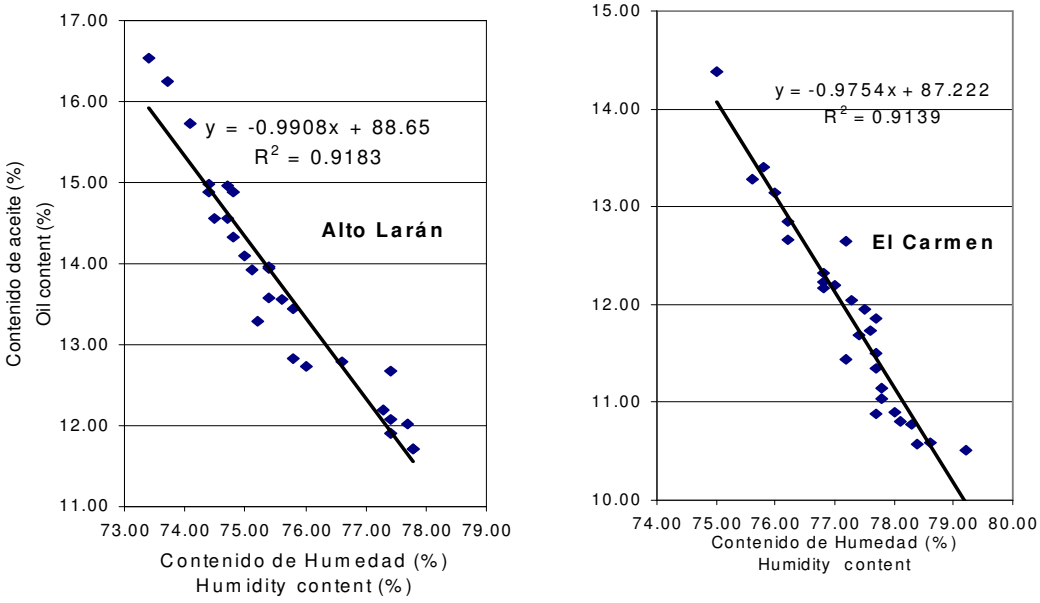

Figure 2: Oil content in avocado fruits (*Persea americana* Mill) var. Hass in function of the pulp moisture.

Respiration intensity: The behavior of typically climacteric respiration presents a particular evolution of the fruits depending on their location of origin (Fig.3). The fruits produced in Alto Larán show their moment of climacteric crisis 16 days after harvest, except in the third week when the climacteric crisis

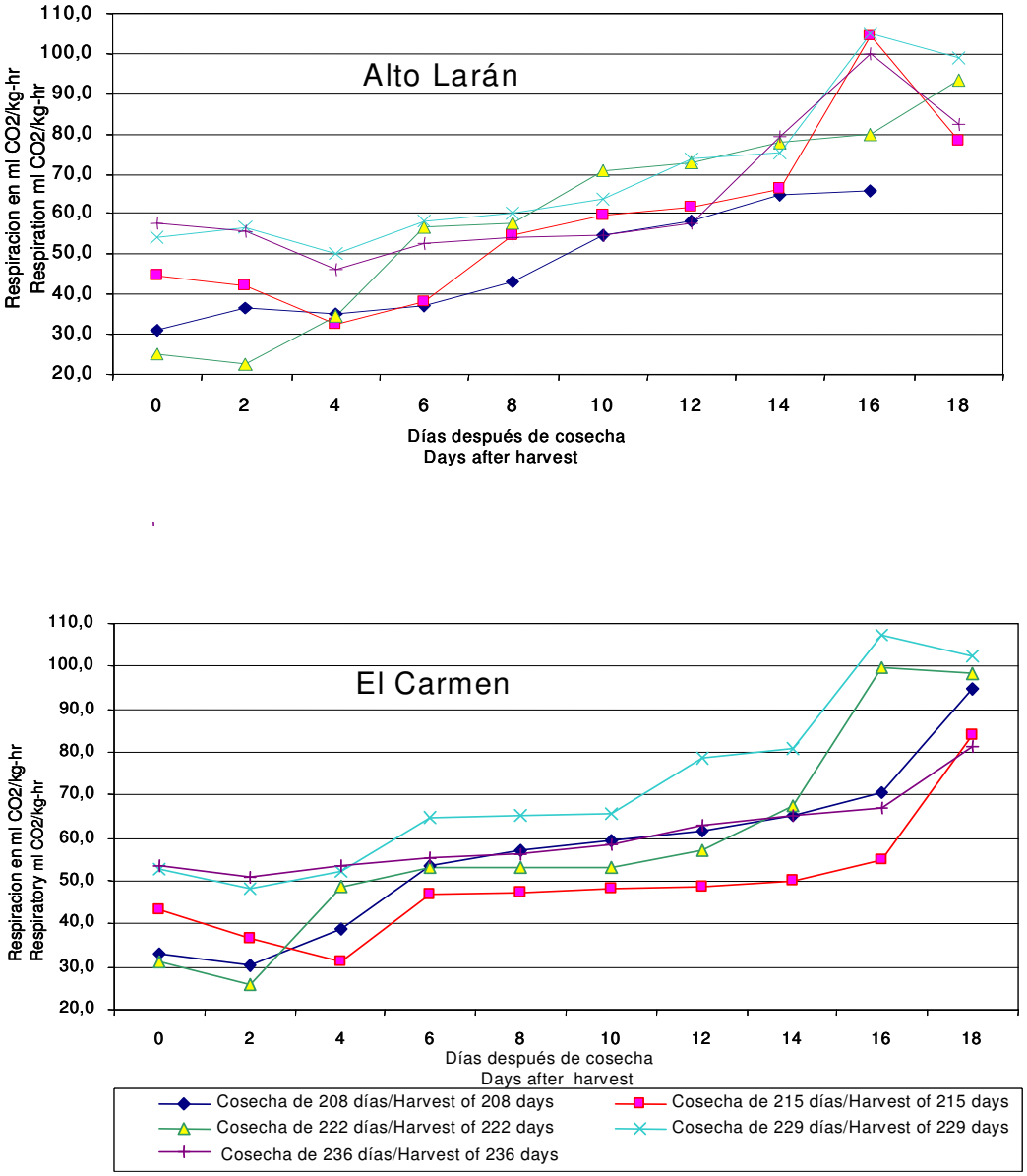

Figure 3: Respiratory curve of avocado fruits (*Persea americana* Mill) var. Hass harvesting by seven weeks in Alto Larán and El Carmen.

occurred on day 18, with maximum values between 93.4 and 105.0 ml CO_2 kg-h^{-1}. Nevertheless, the fruits obtained from El Carmen reached the moment of climacteric crisis on day 18, except in the cases of the third and fourth weeks when the climacteric crisis occurred on day 16, with maximum values between 81.4 and 107.1 ml CO_2 kg-h^{-1}. Generally, the registered levels of respiratory intensity fall within the ranges considered for Hass avocado fruits (Briceño 1994; Eaks 1978). However, it is important to remark that fruits produced in Alto Larán tend to soften faster than those obtained at El Carmen, due to the set of external conditions or management conditions under which plantations produce in each location. This aspect determines the particular behavior during the postharvest maturity process of avocado fruits (Kader, 1992; Pantastico, 1975).

Changes in the oil content, dry matter and pulp moisture:

The oil and dry matter contents and the pulp moisture for each evaluated location showed statistical differences regarding the harvest moments. The obtained results of oil contents showed that it increased while the harvest of fruits was performed each time later (Fig.4). Under Alto Larán conditions the highest results of oil content were obtained at 243 asf (14.63%) and 250 asf (15.85%), while The Carmen showed the highest values of oil content at 243 asf (12.58%) and 250 asf (13.44%). The variation in oil content was 3.82% from the first to the last moment of harvest at Alto Larán, while the same indicator was 2.38% at El Carmen. It means that fruits produced in Alto Larán showed values of oil content somewhat higher than those obtained at El Carmen. Likewise, the dry matter content also increased as the harvests were performed each time later (Fig 5). The picked fruits from Alto Larán reported increases since the harvest that was performed at 222 asf; later these values stood until a level of 243 asf and at the end they reached a level of 250 asf. El Carmen response was similar to the one obtained at Alto Larán: an increase in dry matter of fruits was observed since the level of 222 asf, then it stood until a level of 243 asf and it showed again a light increase at 250 asf. However, El Carmen always showed values of dry matter content lower than those obtained from Alto Larán at any of the harvest moments. In terms of moisture content of the pulp, it showed a downward trend during the harvest period. The fruits obtained from Alto Larán showed at 222 asf a first remarkable change in their moisture content, which didn't report great differences until a level of 243 asf and then decrease again at 250 asf. El Carmen showed a similar trend but with lower values of moisture content in fruits. The trends observed in terms of oil and dry matter and moisture contents of the pulp are related to those reported by other authors (Cajuste, 1992; Lee et al., 1983; Lewis, 1978; Ranney, 1991). Likewise, the increases of oil and dry matter contents as well as the steady decrease of moisture content in Hass avocado fruits, while the harvests for both locations are performed each time later, clearly show the fruit capability of Hass avocado tree to accumulate oils while it remains on tree (Parodi 1996).

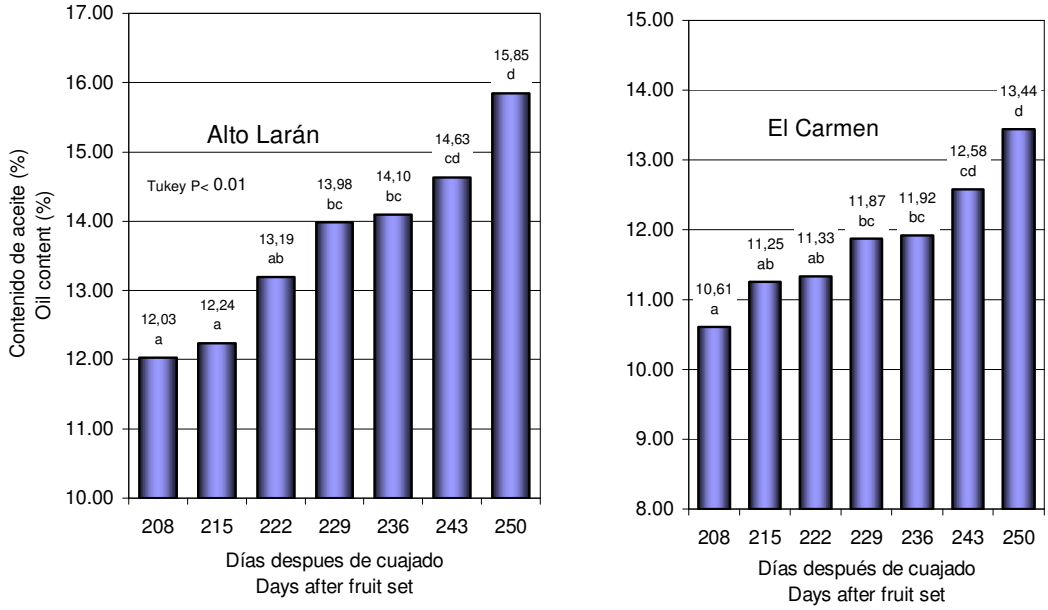

Figure 4: Oil content changes in avocado fruits(*Persea americana* Mill) var. Hass to differents harvest moments.

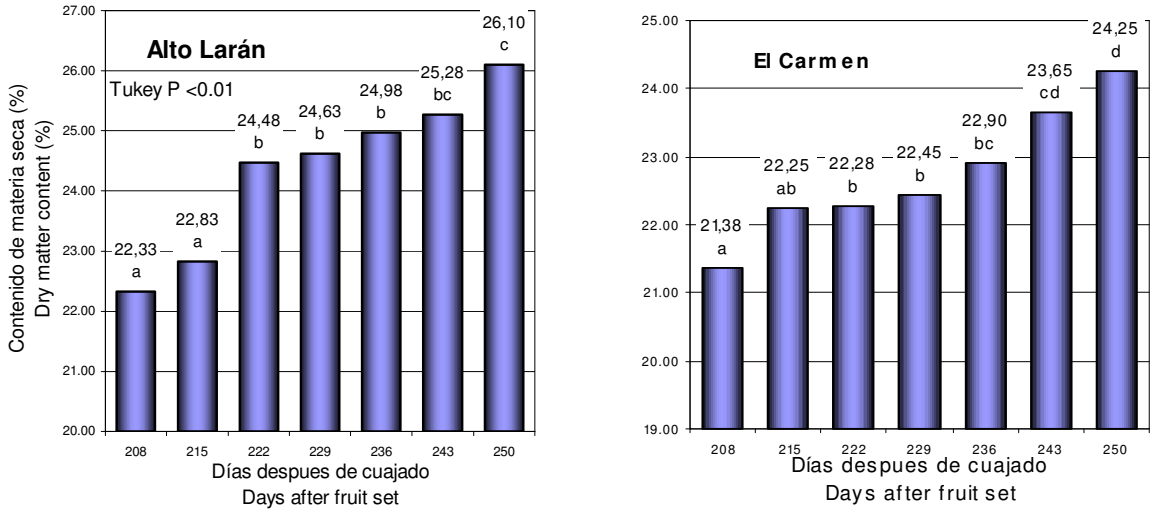

Figure 5: Dry Matter changes in avocado fruits (*Persea americana* Mill) var. Hass to differents harvest moments.

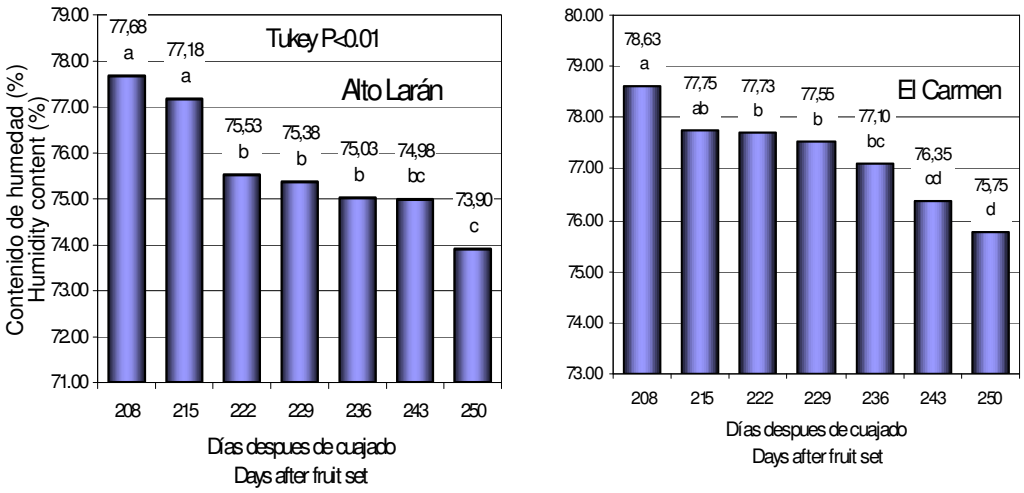

Figure 6: Pulp moisture changes in avocado fruits (*Persea americana* Mill) var. Hass to differents harvest moments.

4.Conclusions

- The oil and dry matter contents showed a positive correlation at Alto Larán (r =0.9583) and at El Carmen (r =0.9544).
- The oil content and the fruit moisture had a high inverse correlation at Alto Larán (r = - 0.9583) and at El Carmen (r = - 0.9544).
- The fruits produced in Alto Larán had a climacteric crisis 16 days after harvest, while at El Carmen the climacteric crisis was on day 18.
- The percentages of oil and dry matter showed an upward trend, while the harvests were performed each time later.
- The moisture content showed a progressive downward trend, while the harvests were done each time later.

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