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EVOLUTION OF THE CONTENT OF OIL AND UNSAPONIFIABLE COMPOUNDS IN HASS, FUERTE AND ISABEL AVOCADOS (*Persea americana* Mill.)

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Avocados have good oil quality and antioxidant properties which make them a healthy product. In the present test, the evolution and composition of oil were determined, as well as, unsaponifiable compounds: Beta-sitosterol and phytosterols, desmosterol, campesterol, epicoprostanol, comprostan 3-one and comprostan 3-ol in Hass, Fuerte and Isabel avocados. To do this, fruits of similar weight (150 and 200g) were collected every 15 days, from August to December for Hass, July to October for Fuerte and September to January for Isabel, determining in each sampling date the percentage of oil. When the varieties reached the minimum percentage of oil for harvest (9% in Hass, 10.36% in Fuerte and 11.8% in Isabel), the extraction of oil started for each variety, determining the composition of fatty acids and unsaponifiable compounds. The extraction of oil was done every 15 days, until the varieties reached their maximum percentage of oil (19% for Hass, 22% for Fuerte and 20% for Isabel). During the season it was concluded that in each variety, there was a development in the content of oil and fatty acids, such as palmitic, palmitoleic, stearic, linoleic, linolenic and oleic acids, with the last being found in greater proportion.

Key words: maturity, oleic acid, linoleic acid, phytosterol, beta-sistoterol, desmosterol.

EVOLUCIÓN DEL CONTENIDO DE ACEITE Y COMPUESTOS NO SAPONIFICABLES EN PALTAS (*Persea americana* Mill.) CVS. HASS, FUERTE E ISABEL

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La palta es un fruto que posee una buena calidad de aceite y propiedades antioxidantes que la hacen ser un alimento saludable. En el presente ensayo se cuantificó la evolución y composición del aceite, así como, los compuestos no saponificables: betasitosterol y fitosteroles desmosterol, campesterol, epicoprostanol, comprostan 3-ona y comprostan 3-ol, en paltas cvs. Hass, Fuerte e Isabel. Para esto, se recolectaron frutos de peso homogéneo (150 y 200g) cada 15 días, desde agosto a diciembre para Hass, de julio a octubre para Fuerte y de septiembre a enero para Isabel, midiéndose en cada fecha de muestreo el porcentaje de aceite. Cuando cada variedad alcanzó el porcentaje de aceite mínimo para cosecha (9% en Hass, 10,36% en Fuerte y 11,8% en Isabel) se comenzó con la extracción de aceite para cada una de las variedades, midiéndose la composición de ácidos grasos y de compuestos insaponificables.

La extracción de aceite se realizó cada 15 días, hasta cuando cada variedad alcanzó su máximo porcentaje de aceite (19% para Hass, 22% para Fuerte y 20% para Isabel). Se determinó que durante la temporada, en cada variedad, hubo una evolución en el contenido de aceite y de ácidos grasos, tales como el ácido palmítico, palmitoleico, esteárico, linoleico, linolénico y oleico, encontrándose este último en mayor proporción.

Palabras clave: madurez, ácido oleico, ácido linoleico, fitosterol, betasistoterol, desmosterol.

1. Introduction

Avocados have good oil quality and antioxidant properties which make them a healthy food product. These fruits are characterized by having a great level of the following: proteins, minerals, vitamins, unsaturated oils (oleic acid, palmitic acid, linoleic acid, among others) and antioxidants (unsaponifiable compounds) (Esteban, 2000; Olaeta *et al*., 1999). However, there is no information available on the evolution of the latter inside the fruit.

As the fruit grows, a considerable increase can be noticed in the oil content and at the same time, each variety presents typical curves (Olaeta and Undurraga, 1995; Saavedra, 1995; Olaeta, *et al.,* 1999).

Avocado oil has a percentage ranging from 70 to 77 % of monounsaturated fats, from which around 96% is composed by oleic acid, whereas the remaining 4%, called polyunsaturated, are mostly represented by linoleic acid and help reducing LDL (bad) cholesterol, established in the arteries (Human, 1987; Inoue and Tateishi 1995; Olaeta *et al*., 1999; Vergara, 2005; Zamora, 2005).

It also has unsaponifiable lipids, which do not correspond to that lipid matter without fat acids in its structure that do not produce saponification reactions and that have antioxidant properties, which reduce cholesterol and prostratic hyperplasia (Fierro *et al.,* 2005) and are important for human health. Some of the unsaponifiable lipids are: terpenes, prostaglandins and sterols. This last group includes Beta-sitosterol and Phytosterols (Licata, 2007). ß-sitosterol is probably the most abundant sterol of plants and widely distributed (Fierro *et al.,* 2005). More than 40 plant sterols have been identified, with Beta-sitosterol and campesterol (both present in avocados) (Hendriks *et al*., 1999) being the most abundant ones. In this fruit, Beta-sitosterol represents between 0.45 and 1% and prevents the organism from absorbing the damaging cholesterol (LDL). In addition, it contains Phytosterol, which is widely used in cosmetics because of its penetration system in the skin (similar to lanolin) (Olaeta, 1991).

In order to contribute in knowing these important compounds during the growth of avocados, through this trial the evolution and composition of oil and unsaponifiable compounds Beta-sitosterol and phytosterols were quantified:

desmosterol, campesterol, epicoprostanol, comprostan 3-one and comprostan 3-ol in Hass, Fuerte and Isabel avocados.

2. Materials and methods

Hass, Fuerte and Isabel avocado fruits of uniform weight (150 and 200 g) were collected every 15 days, from August to December for Hass, from July to October for Fuerte and from September to January for Isabel. The fruits were obtained at the Experimental Station La Palma of the Faculty of Agricultural Sciences, Pontificia Universidad Catolica de Valparaiso, located in Quillota (Latitude 32° 49' S, Longitude 71° 16'W). To carry out the above, 4 trees per variety were randomly marked in May 2006.

In every sampling period 16 fruits (4 per tree) were harvested, in each variety, randomly collected from the periphery of the tree, at a height of 1 – 1.5 m from the soil, and subsequently, taken to Postharvest Laboratory of the Faculty of Agricultural Sciences, determining the following: percentage of oil per Soxhlet (A.O.A.C., 1990) and the percentage of dry matter (A.O.A.C., 1990).

When each variety reached the minimum percentage of oil for harvest (9% in Hass, 10.36% in Fuerte and 11.8% in Isabel, according to Olaeta *et al.*, 1986; Undurraga *et al.*, 1987; Olaeta and Undurraga, 1995), the composition of fat acids and unsaponifiable compounds was determined (A.O.A.C., 1990): β sistosterol and Phytosterols: Desmosterol, Campesterol, Epicoprostanol, Comprostan 3-one and Comprostan 3-ol, by gas chromatography, with the samples derivatized to its methyl-silyl derivative for its subsequent separation and identification with mass selective detector, according to the description by Egan *et al.* (1988). These determinations were made until every variety reached its maximum percentage of oil in the tree: 19% for Hass (López, 1998), 22% for Fuerte (Latorre, 1994) and 20% for Isabel (Bontá, 2006).

For each variety, a simple factorial design was used, where the treatments were the harvesting dates, with 4 replications each. The experimental unit was 4 fruits.

For each variety, regressions were established between: % of oil and unsaponifiable compounds; % of oil and fat acids; fat acids and unsaponifiable compounds.

3. Results and discussion

Evolution of content of dry matter, moisture and oil in each of the varieties

In the Hass variety, the oil content evolves from 8.83 to 13.37%, whereas the content of dry matter varies from 22.47 to 30.47%, and moisture from 77.53 to 69.63%. For the Fuerte variety, the oil content evolves from 12.43 to 20.14%, whereas the content of dry matter varies from 24.04 to 31.38%, and moisture from 75.96 to 68.62%. Finally, for the Isabel variety, the oil content evolves from

12.46 to 18.72%, whereas the content of dry matter varies from 24.22 to 30.42%, and moisture from 75.78 to 69.59%, values similar to those obtained by Olaeta *et al.* (1986); Undurraga *et al*. (1987); Olaeta *et al*. (1999) (Figure 1, 2 and 3).

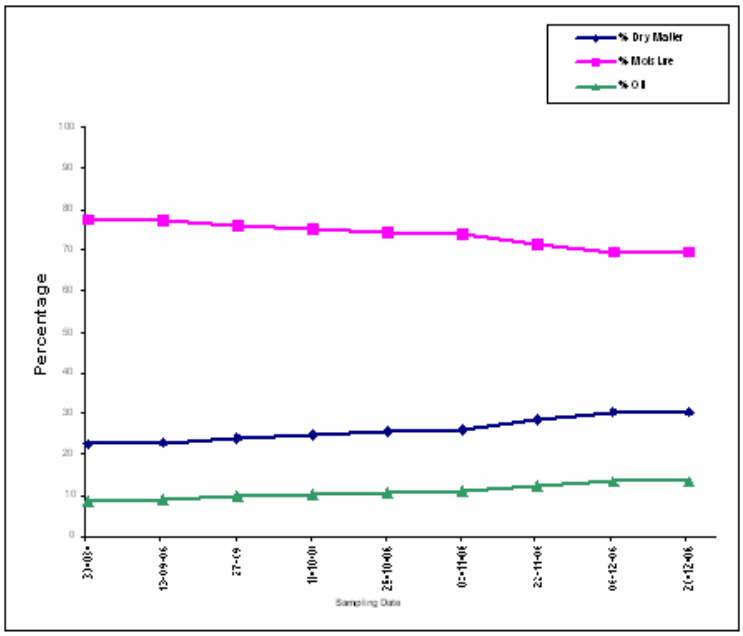

Figure 1: Evolution in the percentage of oil, dry matter and moisture in Hass variety, from August 30 to December 20, 2006, La Palma, Quillota

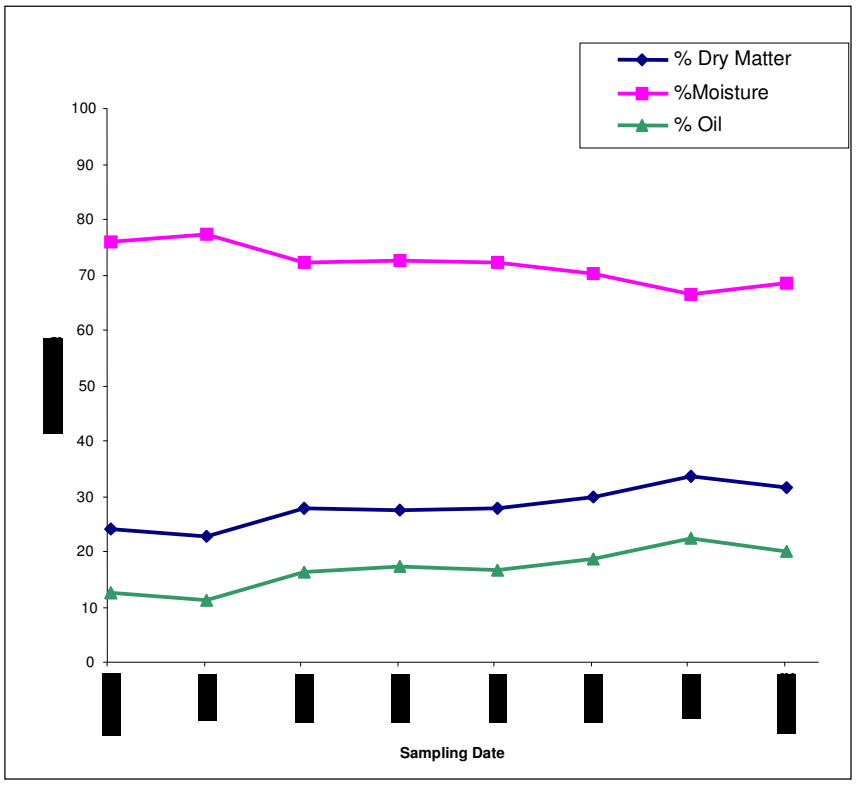

Figure 2: Evolution in the percentage of oil, dry matter and moisture in Fuerte variety from July 12 to October 18, 2006, La Palma, Quillota.

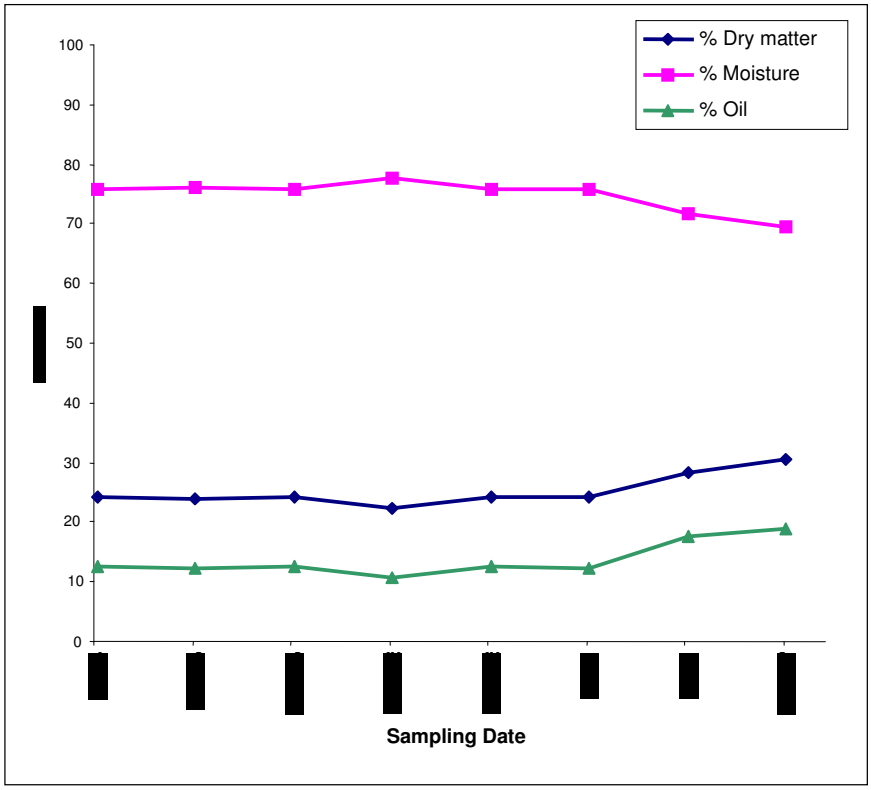

Figure 3: Evolution in the percentage of oil, dry matter and moisture in Isabel variety, from September 27 to January 3, 2006, La Palma, Quillota.

Evolution in the percentage of fat acids during the evaluation periods

The oleic acid ranges from 48.4 to 66.8% in Hass, 71.5 to 73.9% in Fuerte and 62.5 and 77.7% in Isabel, reaching in this variety the highest percentage. The above-mentioned is similar to the result obtained by Messrs *et al.*, quoted by Human (1987), who mentions that the relative percentage of oleic acid in Hass avocado is around 70.5%.

Palmitic and linoleic acids are second in importance. In the Hass variety, they vary between 11 and 13%, and 10 and 13%, respectively. In the Fuerte variety, they range from 9 to 11% and from 8 to 9%, respectively; whereas in the Isabel variety between 7 to 9% and 9 to 10%, respectively. According to the research by Messrs *et al.*, quoted by Human (1987), the palmitic and linoleic acids would be 11.8 and 9.45%, respectively, for Hass avocados (Figure 4, 5 and 6). These values coincide with those reported by Inoue and Tateishi (1995); Olaeta *et al.,* (1999) and Vergara (2005), who state that avocado oil has lipid content with very low saturated fat acids and very high monounsaturated, of which approximately

96% is composed by oleic acid, and the remaining 4%, called polyunsaturated, is are mostly represented by linoleic acid.

The lipid description exposed for each variety was made as from the moment in which they reached their maturity for harvest, and from this point, the content of each fat acid is kept relatively constant through time, except for the oleic acid in Isabel cultivar, in which a considerable rise in this acid can be noticed. In addition, a sharp drop of the oleic acid content can be observed in Hass, which occurs because the development stage of the fruit implies a variation of the lipid content (Appleman *et al.,* 1941).

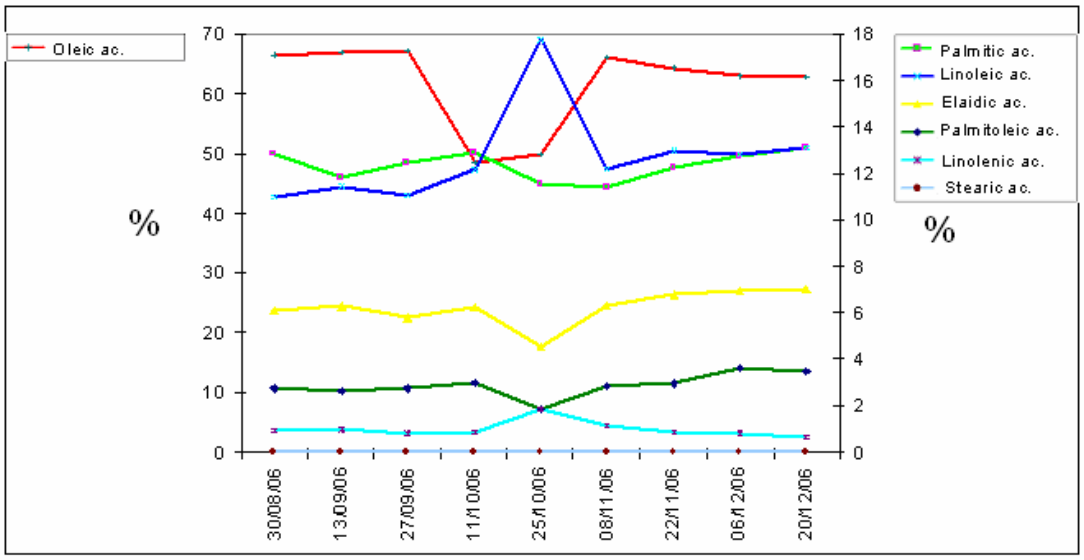

Figure 4: Evolution in the percentage of fat acids in Hass variety, from August 30 to December 20, 2006, La Palma, Quillota.

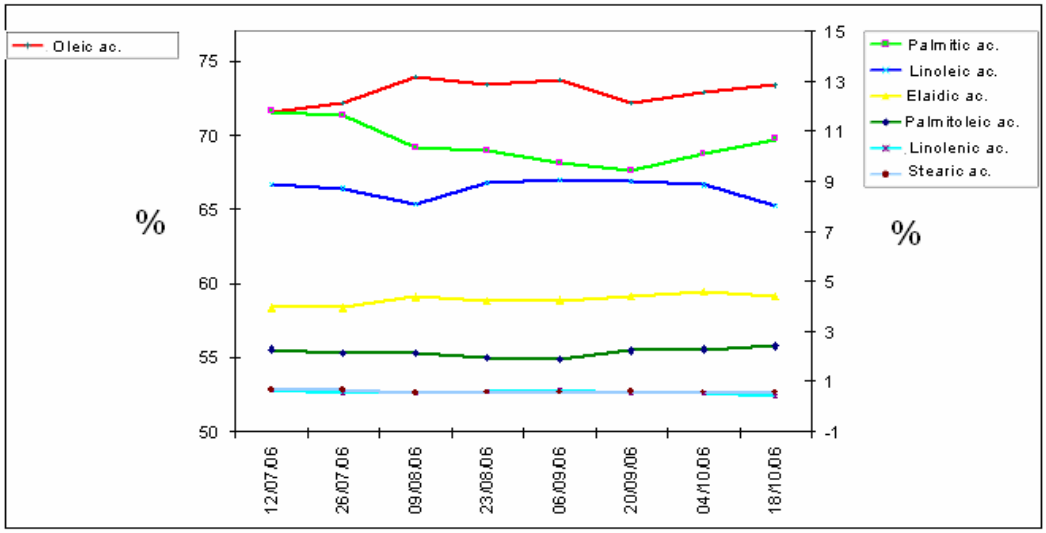

Figure 5: Evolution in the percentage of fat acids in Fuerte variety, from July 12 to October 18, 2006, La Palma, Quillota.

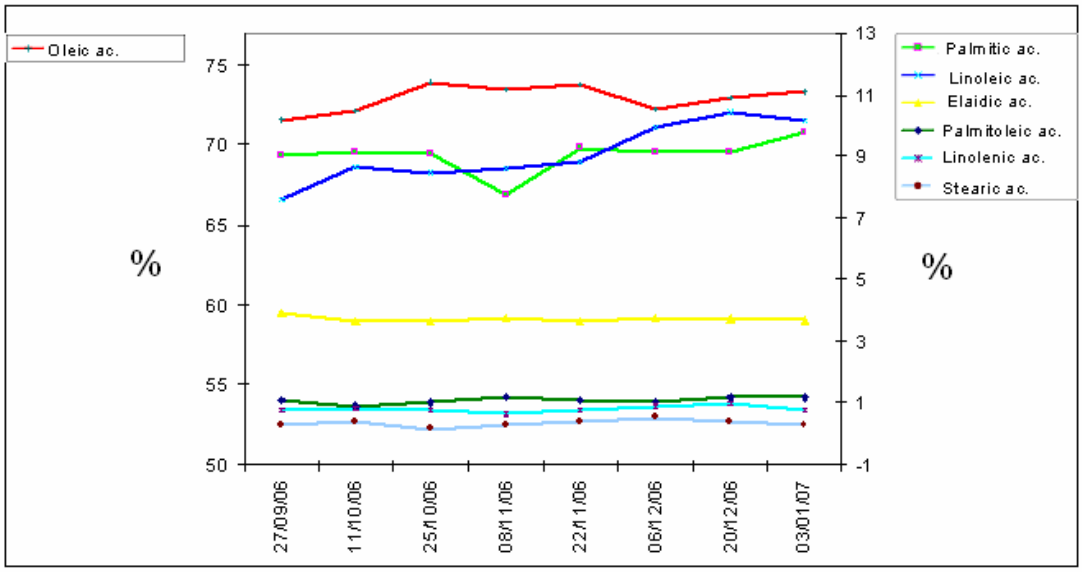

Figure 6: Evolution in the percentage of fat acids in the Isabel variety, from September 27 to January 3, 2006, La Palma, Quillota.

Relation between the evolution of the oil percentage and evolution of each fat acid in each of the varieties

Table 1 only shows significant correlations of some fat acids with the evolution of oil level in avocados. In Hass and Fuerte, there is a correlation between the evolution of oil and elaidic acid, whereas in the Isabel variety, this correlation occurs with linoleic acid, with every variety showing a different relation. This could indicate that the fat acids are transformed during ripening of fruits, modifying their relative proportion (Olaeta *et al*., 1999).

Table 1: Relation between the evolution of the % and the evolution of each fat acid in each of these varieties

HASS VARIETY			
Fat Acid	**R^2**	**R**	**Significance**
Palmitoleic	39.028%	0.624	*
Elaidic	29.033%	0.538	*.
FUERTE VARIETY			
Palmitic	49.881%	0.650	*.
Elaidic	88.972%	0.943	**
ISABEL VARIETY			
Palmitic	41.954%	0.647	*.
Linoleic	51.590%	0.718	**

*Significant at 5%. ** Significant at 1%.

Evolution of the percentage of unsaponifiable compounds

Regarding the three varieties studied, campesterol and ß-sitosterol were only found in detectable proportions. The latter presented 2 consecutive peaks, the first coincided with values close to the minimum percentages of oil defined for harvest in each variety; this was on October 25 for Hass variety with 10.74% of oil, on July 26 for Fuerte with 11.09% and November 8 for Isabel variety with 10.56%. The second peak occurred in a more advanced maturity stage (Figure 7, 8 and 9).

Hass variety showed the highest relative percentage regarding the ß-sitosterol percentage, varying between 0.08% and 0.34%. In Fuerte variety, this was between 0.10 and 0.19%; whereas in Isabel variety 0.13% and 0.31%. The above mentioned coincides with what was obtained by González de Pedro (2005), who states that the unsaponifiable fraction in avocado reaches between 0.5 and 2.5%.

In addition, the differences in the percentages of ß-sitosterol, in relation with the obtained by Fierro *et al.* (2005), are caused by the differences in the values of nutritional level of avocados, which depend on the variety and soil where they grow (Torres, 2005).

With regard to campesterol quantification, the three varieties showed stable percentages during the maturity of fruits.

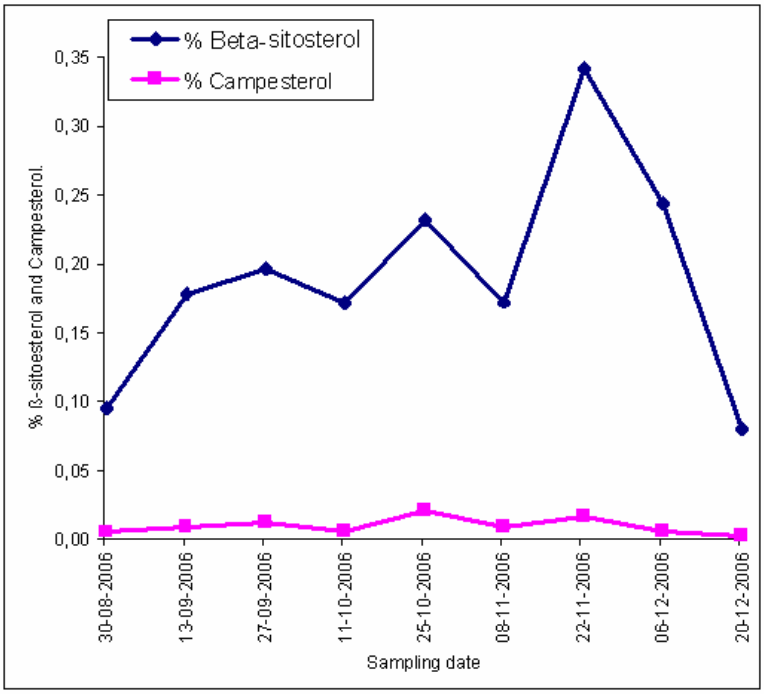

Figure 7: Evolution in the percentage of ß-sitosterol and Campesterol Hass variety, from August 30 to December 20, 2006, La Palma, Quillota.

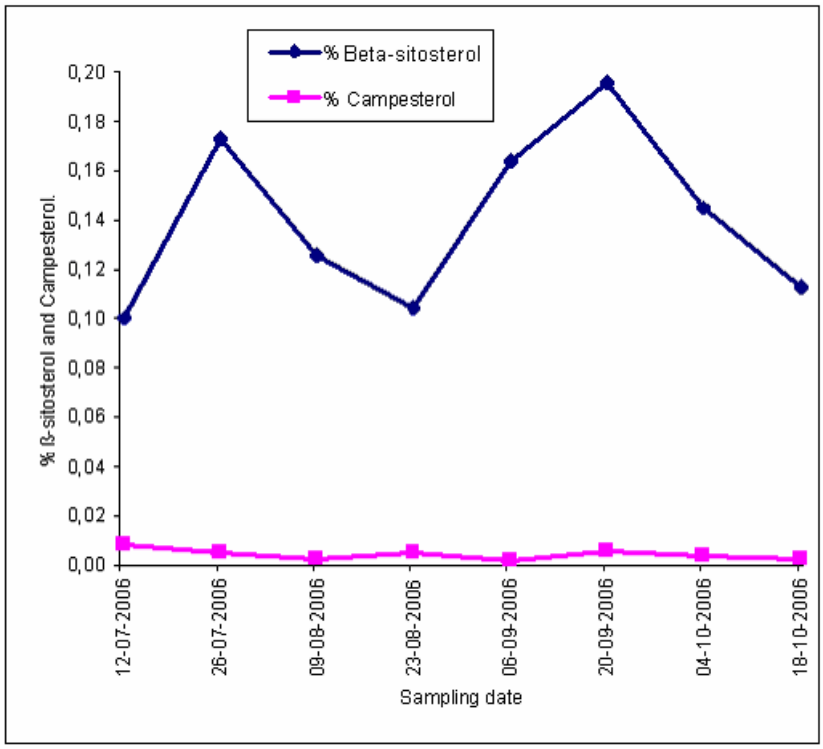

Figure 8: Evolution in the percentage of ß-sitosterol and Campesterol in Fuerte variety from July 12 to October 18, 2006, La Palma, Quillota.

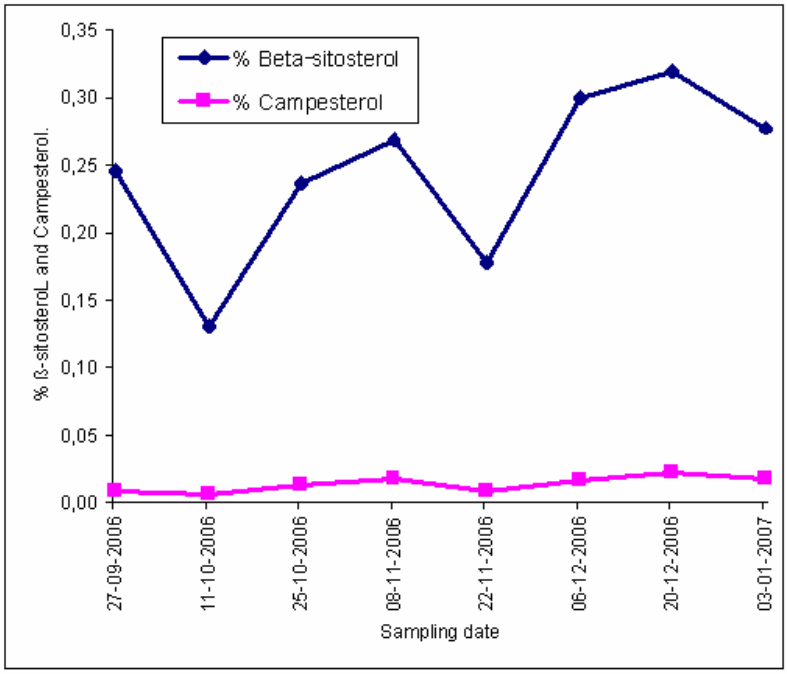

Figure 9: Evolution in the percentage of ß-sitosterol and Campesterol in Isabel variety, from September 27 to January 3, 2006, La Palma, Quillota.

Relation between the evolution of oil % and the evolution of unsaponifiable matter

A significant correlation (R=0.55) was only observed in Isabel variety between the evolution of percentages of oil and campesterol. The above mentioned would indicate that the formation of unsaponifiable components has no direct relation with the oil level of avocado fruits.

Relation between the evolution of unsaponifiable matter and the evolution of fat acids

Likewise, a significant correlation was only noticed in Isabel variety between the evolution of palmitoleic and linoleic acids and unsaponifiable components (R=0.60 and 0.58, respectively), indicating that neither there is no direct relation between the evolution of fat acids and unsaponifiable matters.

4. Conclusions

During the growth of Hass, Fuerte and Isabel avocado fruits, there is an evolution of fat acids and unsaponifiable matter measured as ß-sitosterol and Campesterol from the moment in which the minimum content of oil is reached for an acceptable level of palatability.

Hass, Fuerte and Isabel avocado fruits show a high relative percentage of oleic acid, followed by linoleic, palmitic, elaidic and palmitoleic acids, predominating relatively weak relations between the evolution of the oil content and the evolution of the mentioned fat acids.

Hass and Isabel avocado fruits present high relative percentages of ß-sitosterol.

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