OLIVE OIL ADAPTATION TO TEMPERATURE OF GROWTH
ADATTAMENTO DELL'OLIO DI OLIVA ALLA TEMPERATURA DI ACCRESCIMENTO

Guido Bongi[1*], Claudio Ranocchia[1]

[1] Istituto per i Sistemi Agricoli e Forestali del Mediterraneo. Consiglio Nazionale delle Ricerche (CNR ISAFOM) – via Madonna Alta 128, 06128 Perugia (Italy).
* guido.bongi@cnr.it

Abstract
Oil from fruit flesh modifies the TAG composition when temperature of growth changes. Near pit hardening, a heat burst above 30°C produces a drop in oleic moiety. This decrease is compensated by an increase in either palmitic or linoleic, or both, depending on Cv. The occurrence of this adaptation is an emerging character in austral plantations.

Keywords: *Olea europaea*, oil adaptation, meteorology, fruit physiology.
Abbreviation list: TAG triacyl glycerol, FAE1 Fatty acid elongase 1 promoter, FA160 palmitic, FA180 stearic acid, FA181 oleic acid, FA182 linoleic acid, FA183 linolenic acid %; all FAs are % relative to TAG, OLP is the ratio FA181/(FA160+FA182).

Introduction
The evolution of fats in drupes like Oil Palm, Olive and Avocado does not follow the biosynthetic regulation common to all seeds which are linked to the presence of organized organelles, the oleosomes. In seeds an increase in temperature during oil accumulation leads to an increase in FA181 and a decrease in FA182. A better fluidity at germination is their remote link for this adaptation in evolution (Linder, 2000). Fats in drupe flesh do not behave similarly, but rather FA181 decreases with an increase in temperature (Lombardo et al, 2008). The diurnality, continentality or seasonality thermal component of this adaptation is unknown. Olive oil quality is under debate but a clear relationship exists about the value of mean olive TAG which is linked to a high oleic proportion, the FA181, up to 82%. Antioxidant activity, temperature of condensation and bench life have been thought to depend on genotypic regulation of secondary compounds as well FA 182 and FA160 levels, even if their place of origin has been a traditional criterion for selection. Low oleic % is linked to a decrease in all potential quality indexes even if it is unclear how TAG composition and antioxidant content are interrelated to over ripening or to post-transcriptional regulation of separate pathways. Here we present support to this last proposal by the comparison of the same Cv in contrasting climates under a similar heat sum.

Materials and Methods
We collected several compositional tables from pre-introductory trials in Catamarca (north-west Argentina) from a proprietary oil composition archive of CNR IRO and we had actual climatic records of mean daily temperature, rainfall and solar radiation.
A series from literature was used to add a match set for Picual (Rial and Falqué, 2003), and its climate was taken from LDEO server at the experiment coordinates and elevation (http://iridl.ldeo.columbia.edu/).
A few dataset were then built and are now available in order to separate genetic effect from maturation and environment; here we focus on the case study of Picual in Andalucía and Catamarca. Statistics and plots were done in R-project linear model and functions Matplot and package Hmisc (Harrel and Dupont, 2013).

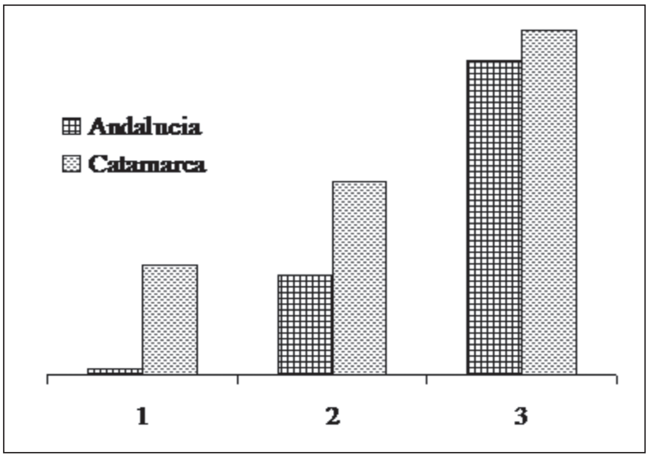

Fig 1 - N°days >30°(1)>27°(2)>24°(3) in the interval from 2 to 4 weeks after pit hardening. Criterion 1 bar lengths represents 1 and 21 days respectively. In meanwhile OLP fell from 5.2 in cv. Picual from Andalucía to 2.5 in Catamarca, but a sharp discrimination occurs only selecting a critical interval and N° days >30°C. The comparison match for discriminant analysis was a series of Picual that was collected under a moderate change in climate but a strong altitude gradient (Rial and Falqué,2000), where there was a change of OLP of 18% and a modelled frequency of criterion 1 from 1 to 6 days.
Fig. 1 - Numero di giorni > di 30°(1),>27°(2),>24°(3) nel periodo tra 2 e 4 settimane dopo l'indurimento del nocciolo. La lunghezza delle barre del criterio 1 è di 1 e 21 giorni rispettivamente. In corrispondenza l'indice OLP è cambiato da 5.2 in Andalusia a 2.5 in Catamarca. Questo discrimine può essere giustificato solo selezionando la condizione (1). Le serie climatiche raccolte avevano caratteristiche omogenee per varietà e somma termica ma erano asincrone nei massimi termici.

Results and Discussion
Contrast analysis on a single Cv in different environments, indicates an early imprinting of Oleic drop in drupes which probably occurs just after pit hardening, when oil content in drupes is minimal, probably when mean daily temperature reached 30°C in this phase (Fig. 1).
This possibility was emerging from the comparison of 2 climatic series with a comparable heat sum but asynchronous in their heat

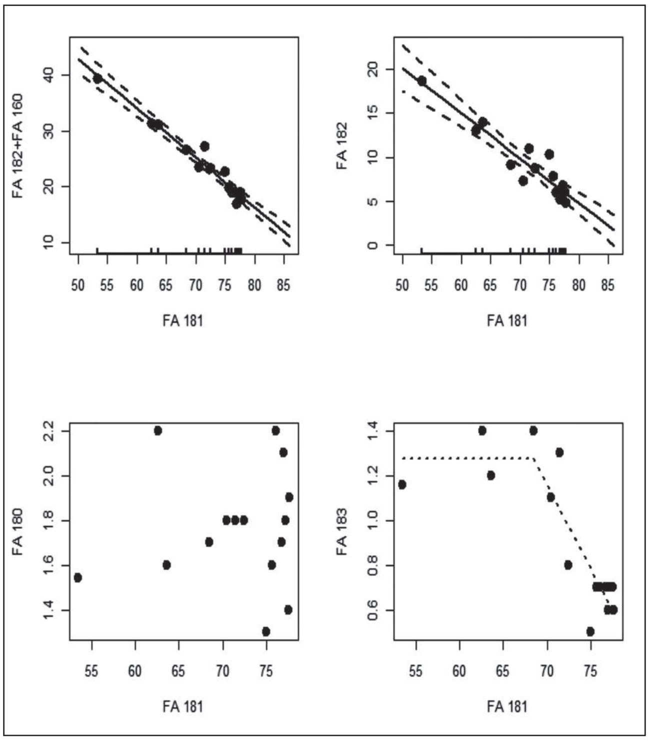

Fig. 2 - 15 different Cv. in different environments follow a hypothesis of control by OLP ratio. Whenever there was a drop in FA181 this change was followed by a variation in OLP. The series were collected under strong variations in heat sum during olive maturation, selecting cases which were over than 40% during 150 days after pit hardening in GDD> 7°C.

Fig. 2 - 15 diverse Cv in ambienti differenti seguono l'ipotesi di controllo da parte dell'indice OLP. In tutti i casi nei quali si è verificato un calo di FA181, questo è stato seguito da una variazione di OLP. Queste serie sono state raccolte sotto un forte gradiente di somma termica durante la maturazione, selezionando casi eccedenti il 40% nella somma termica sopra 7°C nei 150 gg dopo l'indurimento del nocciolo.

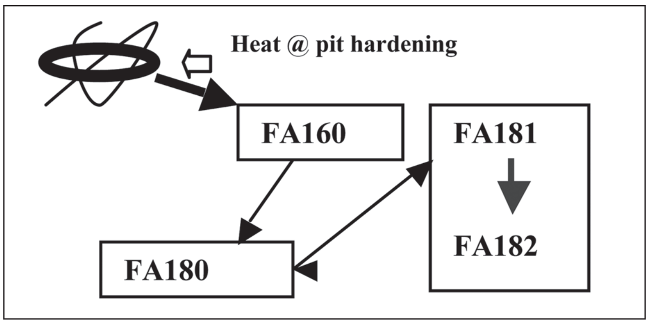

Fig. 3 - The thick ellipse represents chloroplasts; during their formation a high FA160 is stored in membranes which are processed when degradation occurs, into TAG. Arrow thickness depicts flow rates.

Fig. 3 - L'ellisse a tratto spesso rappresenta i cloroplasti; durante la loro formazione una elevata proporzione di FA160 è incorporata nelle membrane e viene utilizzata nei TAG durante la degradazione. Lo spessore delle frecce misura l'intensità dei flussi.

pulses. How relevant it may be is measured by the drop in OLP from 5.2 to 2.5 with a single Cv the Picual, at about the same heat sum at harvest but with a difference in heat pulse timing, with an olive compositional range of OLP between 1.5 and 7.

The variation in FA181 and in the sum of FA182 and FA160 was mutual and compensative across a set of major olive Cvs as shown in figure 2, under the restriction of an high difference in integrated heat sum (GDD>7°C). OLP is a better descriptor than monounsaturated to polyunsaturated fatty acid ratio or single acid ratios in TAGs.

The regression coefficient of determination r^2 dropped from .955 to .869 if FA160 values were removed from OLP. The evidence resulting from statistics is that FA160 is a determinant, along with FA182 of FA181 drop.

Further the regressions with and without FA160 were significantly different at 0.001 of probability in the analysis of variance.

This coincidence of events may suggest an active pool of TAG that has got different timing in different fatty acids, relative to FAE1 activity (Weselake et al. 2009, Liu et al., 2002) such that after several weeks of exposure to heat FAE1 is less active in the FA180 production, accumulating FA160 whereas FA181 desaturase is unaffected and proceeds with desaturation on a previous early pool of FA181.

The mechanisms of memory and promoter regulation are unknown; the absence of oleosomes might suggest an incidental evolution of fat accumulation in drupes due to the impairment of lipid catabolism functions under photosynthetic cell membrane degradation (James et al., 2010, Fig.3).

It is therefore possible to do a revision of composition tables by using OLP criterion, say the slope of a plot of FA160+FA182 against FA181 with early summer mean temperatures.

Heat pulses possibility during fruit set pose a critical limit to olive oil quality in face of climatic changes or to new introductions.

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