Genotype-Environment-Year Interaction on Oil Antioxidants in an Olive District of Northern Italy

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Keywords: autoxidation stability, cultivar, *Olea europea* L., polyphenols, tocopherols

Abstract

A two-year survey in 18 representative groves of a north Italian olive district sampled cvs. 'Casaliva' and 'Leccino' for single-site oils. Polyphenols had a major role in determining oil autoxidation stability with respect to tocopherols, even if the higher autoxidation stability of 'Leccino' over 'Casaliva' was probably due to the more than double content in tocopherols, which was significantly affected by years. In spite of the large variations both in oil and in environmental parameters, no statistically significant model emerged for relations between antioxidants oil content and site parameters.

INTRODUCTION

Antioxidant properties represent one of the most important quality aspects of virgin olive oil, determining its shelf life and nutraceutical attributes (Castelli et al., 1999; Ryan et al., 1998). Polyphenols and tocopherols play an important role in autoxidation stability, whereas the effects of carotenoids and chlorophyll are more complex due to a shift from an antioxidant nature in the dark to a pro-oxidant activity in the light (Haila et al., 1996). Despite important research devoted to technological process improvement to keep the antioxidant level in virgin olive oil high (Malfatti et al., 2000), scant information is available about the genetic and ecophysiological causes of variation in antioxidant content in olive fruit (Bruni et al., 1994).

MATERIALS AND METHODS

The survey was conducted in 18 olive groves of 'Casaliva' and 'Leccino' cultivars in a growing district of northern Italy located on the south-west side of Lake Garda in 1997 and 1998. Five landscape units were selected for their possible interest to olive growing (Minelli, 1997): glacial tills (3 groves), outwash plains (3), linkage surfaces between tills and plains (6), contact and kame terraces (4), and high lake-coast (2). Land morphology extended from plane to steep slopes modified by artificial terraces, soils from shallow to medium in depth (40-120 cm), from free to rich in skeleton (0-40%), from sandy loam to clay loam texture, from low to high in available water content (60-200 mm), and elevation from 80 to 250 m asl. Four adult trees of average vegetative and yield performance were selected per grove and in each year oil was extracted during veraison from the fruit of a single tree after Tura et al. (2002); olive maturity index was evaluated before oil extraction after the Uceda (1983). Phenolic compounds (Angerosa et al., 1995), tocopherols (Andrikopoulos et al., 1989) and autoxidation stability (AOS: Gutierrez, 1989) were determined and the data processed with the SPSS for Windows v. 9.0 statistical package.

RESULTS AND DISCUSSION

The two-year maturity index of the harvested olives ranged from yellowish-green to black skinned fruit with the flesh not completely darkened (Table 1). In 1997 the higher air temperature and the lower rainfall recorded from September to October induced an earlier ripening than in 1998 (data not shown); note that 'Leccino' ripens three-four weeks earlier than 'Casaliva'. Wide-ranging variability values were detected for polyphenols and tocopherols, while no significant differences in oil polyphenols were detected in comparing cultivars, years and their interaction (Table 1). A significant difference in tocopherol was found when comparing cultivars or years, i.e. 'Leccino' oil contained more than twice the tocopherols than 'Casaliva' and in 1997 the tocopherol content was double that of the following year. The AOS showed a wide range as well and was significantly different between cultivars, with 'Leccino' showing 50% higher values, although it was not statistically different between years. Polyphenol content was not correlated to tocopherols, neither for the single cultivar x year combination nor for all the data taken together. When processed by multiple regression following a step-wise method, the AOS was correlated to polyphenol and tocopherol content. According to the regression model, the AOS was mainly affected by the polyphenol levels: 1 ppm of total polyphenols determined twice the increase in AOS than the tocopherol's (AOS = 6.1 + 0.54 * polyphenols + 0.24 tocopherols; r = 0.73); the cultivar difference in AOS was consequently due to tocopherols (Figure 1). Comparing polyphenols and AOS levels with the fruit maturity index showed no significant cultivar correlation in 1997. A significantly high correlation between maturity index and polyphenol levels was detected in 'Leccino' oils in 1998. A similar trend was also found for 'Casaliva' oils, even if the significance of the correlation was above the 5% level (Figure 2). While tocopherol levels were related to fruit maturity index when the two-year data were pooled, no relations emerged within the same cultivar x year combination (Figure 3). Site and soils descriptors were unable to explain even part of the large variations in fruit maturity and autoxidation properties.

CONCLUSIONS

Our two-year data indicate an adequate antioxidant properties of oils, as also detected by Poiana et al. (1999), although marked variations in polyphenols, tocopherols and autoxidation stability were detected in our survey. Polyphenols played a major role in determining autoxidation stability with respect to tocopherols, even if the higher autoxidation stability of cv. 'Leccino' oils was in all liklelihood due to their having double the tocopherol content with respect to 'Casaliva' oils. Years had a significant effect on tocopherols and a minor effect on autoxidation stability. A positive relation between fruit maturity index and polyphenol content was detected, particularly in 'Leccino' for one of the two years. In spite of the large variations both in oil and in environmental parameters, no statistically significant model emerged for relations between antioxidants and site parameters. Therefore, the causes of the marked variability in fruit maturity and antioxidant properties require further investigation. Plant physiological status and possible cultivar clonal variations should be taken into greater account.

ACKNOWLEDGEMENTS

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Tables

Table 1. Maturity index, total polyphenols (ppm of resorcinol), total tocopherols (ppm $\alpha+\delta+\gamma$ tocopherol) and autoxidation stability (AOS): main frequency distribution parameters, cultivar and year comparisons.

	Total samples					Cultivar[1]		Year[1]	
	No.	Mean	Sd	Min	Max	Casaliva	Leccino	1997	1998
Maturity index	37	3.4	1.1	1.4	5.1	2.7a	4.1b	4.1a	2.8b
Polyphenols (ppm)	36	143	83	24	369	154a	130a	120a	161a
Tocopherols (ppm)	37	161	96	42	416	97a	228b	217a	114b
AOS (days/kg)	37	120	58	40	254	94a	146b	103a	134a

[1] In rows: values followed by the same letter are not statistical different for P $\leq$ 5 %.

Figures

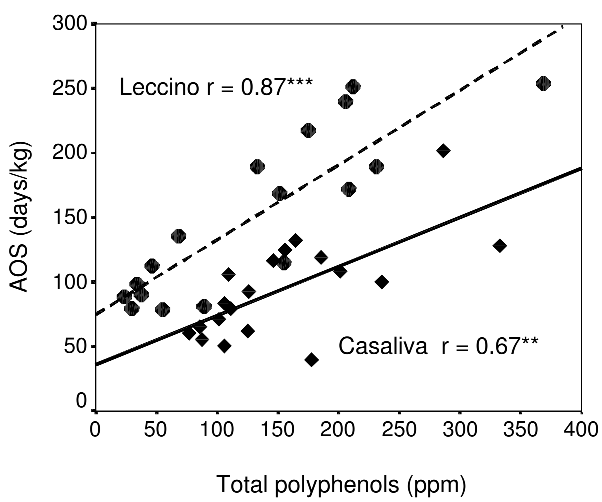

Fig. 1. Regression between polyphenols and antioxidant stability in mono site oils (1997 and 1998).

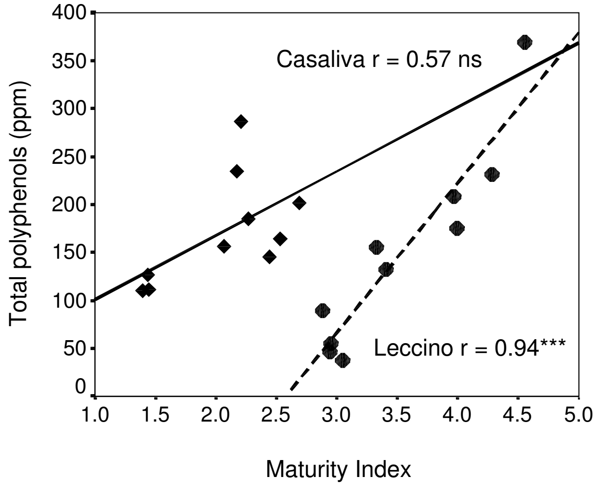

Fig. 2. Regression between olive maturity index and polyphenols (1998).

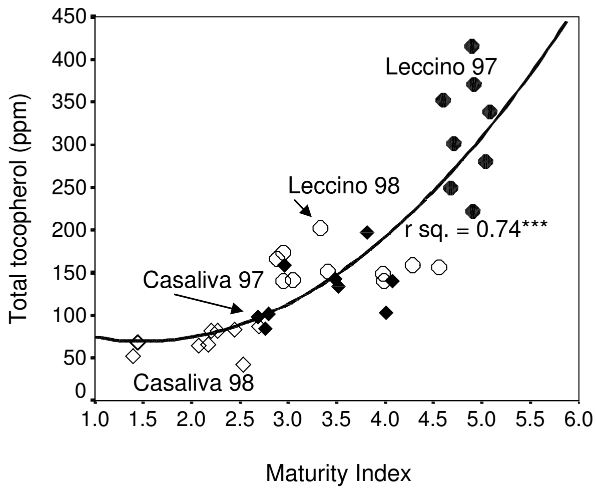

Fig. 3. Regression between olive maturity index and tocopherols (1997 and 1998).

GENOTYPE-ENVIRONMENT-YEAR INTERACTION ON OIL ANTIOXIDANTS IN AN OLIVE GROWING DISTRICT IN NORTHERN ITALY

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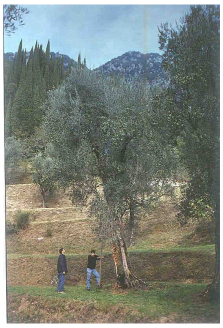
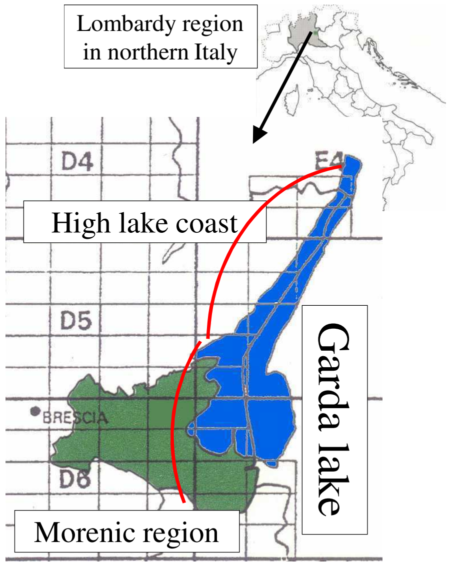
A two year survey was conducted in an olive growing district of northern Italy, 18 representative orchards were chosen. 'Casaliva' and 'Leccino' cultivars were sampled to obtain mono site oils.



High lake-coast

Landscape units	Site n°	Site characteristics
End and lateral moraine ridges	3	Olive orchards are on slopes modified by artificial terraces. Soils are shallow (40-60 cm), rich in skeleton (30-40%), sandy loam textured, low in AWC[1] (60-80 mm). Site altitude ranges from 140 to 215 m a.s.l.
Outwash plains	3	Lands are plane or sub plane. Soils are from shallow to medium in depth (60-120 cm), rich in skeleton (20-30%), clay-loam textured, medium or high in AWC[1] (120-200 mm). Site altitude is around 140 m a.s.l.
Linkage surfaces between moraines and plains	6	Lands are slightly sloped (3-5%). Soils are from shallow to medium in depth (40-120 cm), from free to rich in skeleton (0-40%), from sandy-loam to clay-loam textured, from low to high in AWC[1] (60-120 mm). Site altitude ranges from 80 to 180 m a.s.l.
Contact and kame terraces	4	Lands are plane or sub plane. Soils are from shallow to medium in depth (60-120 cm), rich in skeleton (20-30%), sandy-loam textured, from medium to high in AWC[1] (80-120 mm). Site altitude ranges from 160 to 250 m a.s.l.
High lake-coasts	2	Olive orchards are on steep slopes modified by artificial terraces. Soils and sites characterisation is still in progress.

1 AWC = available water content

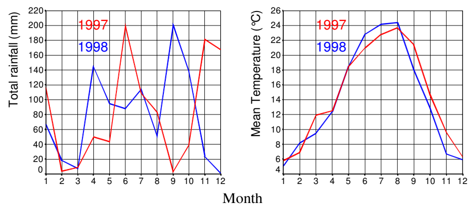


Moraine ridges

Linkage surfaces

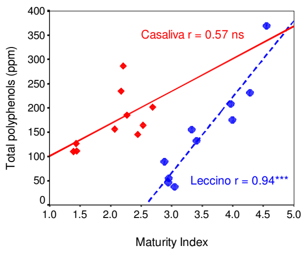
Outwash plains

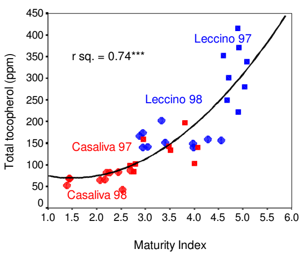
Terraces



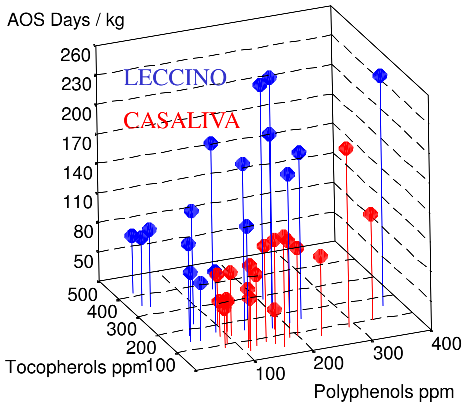
In 1998, September and October were cooler and more rainy than 1987, this induced a later fruit ripening

In 1998 a significant high correlation between maturity index and polyphenol levels was detected in 'Leccino' oils. A similar trend was seen also for 'Casaliva' oils, even if the significance of the correlation was above the 5% level.





Tocopherols levels were related to fruit maturity index pooling together the two year data, but no relations emerged within the same cultivar x year combination.



- AOS was correlated to polyphenol and tocopherol content by multiple regression, following a step wise method.
- AOS was mainly affected by the polyphenol levels: one ppm of total polyphenols determined an increase in AOS twice than tocopherol.
- AOS showed an ample variability range as well was significantly different between cultivars, with 'Leccino' showing 50% higher values.
- The cultivar difference in AOS were due to tocopherols

$$AOS = 6.1 + 0.54 * \text{Total polyphenols} + 0.24 \text{ Total tocopherols};\ r = 0.73;\ r^2 = 0.53.$$

CONCLUSION

- Polyphenols had a major role in determining oil antioxidant stability in respect to tocopherols.
- The higher antioxidant stability of 'Leccino' vs. 'Casaliva was likely due to the more than double content in tocopherols.
- Tocopherols were significantly affected by year.
- In spite of the large variations both in oil and in environmental parameters, no statistically significant model emerged for relations among antioxidants and site parameters (i.e. landscape unit, altitude, soil depth, texture, available water content).