

# Free Radical Research

Official Journal of the Society for Free Radical Research-European Region



*Managing Editors*  
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## European Research on Functional Effects of Dietary Antioxidants: Benefits and Risks

25th-28th September 2002, Cambridge, UK

Abstracts and Plenary Lectures

Co-ordinating Editor: Dr Siân Astley

lutein was still significantly associated with MP density after adjustment for age, total cholesterol, BMI and smoking.

## CONCLUSION

The associations between MP density and serum lutein, serum zeaxanthin and adipose lutein concentrations are stronger in men than in women.

**Keywords:** carotenoids; lutein; zeaxanthin; subjects; macular pigment density

## ACKNOWLEDGMENTS

This project was sponsored by Unilever Health Institute, Unilever Research and Development, Vlaardingen, The Netherlands

## Comparative Antioxidative Properties of Selected Seed Oils

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## INTRODUCTION

Vegetable oils are very important components in arteriosclerosis preventing diets. Nutritional antioxidants with polyphenolic compounds in the lead can prevent lipid peroxidation<sup>1,2</sup>. Some authors attributed the positive influence of diets to their low saturated and high monounsaturated fatty acid content<sup>3</sup>. The major aim of this study was to evaluate antioxidative properties in four widely used seed oils: sunflower, sunflower high oleic, rapeseed and grapeseed oils. Crude and refined oils were also compared.

## MATERIALS AND METHODS

Total radical-trapping antioxidative potential (TRAP) of acetone extracts was measured luminometrically as the ability to trap peroxy radicals produced at a constant rate by thermal decomposition of 2,2-azo-bis-2-amidinopropane hydrochloride. Trolox, a water-soluble analogue of tocopherol was used as a reference inhibitor instead of sample. The results obtained were expressed as nmol of peroxy radicals trapped by 1 ml of sample. Fatty acids and sterols were determined according to the International Olive Oil Council. Total polyphenols were determined by Folin-Ciocalteu method and measured spectrophotometrically at 675 nm. Stability was evaluated by measuring the oxidation induction time at 100°C. All data were expressed as means  $\pm$  SD ( $n = 5$ ). The data were analysed by one-way analysis of variance (ANOVA) and Student's *t*-test with a level of significance of  $p \leq 0.05$ . Spearman correlation coefficient (*R*) was used to show correlations between various parameters.

## RESULTS AND CONCLUSION

The highest total content of oleic, linoleic and linolenic acids (90.2% and 91.1% of total fatty acids in crude and refined oils, respectively) was found in sunflower high oleic oil (see Table I).

The most important, biologically active linoleic acid was a dominant fatty acid in grapeseed oils. The content of linoleic acid in sunflower oils was also relatively high. Out of the fatty acids studied, myristic, palmitic, and palmitoleic acids contributed to the total fatty acid content to a minor extent only. Results on the content of various groups of antioxidant compounds in the studied oils are summarized in Table II. The highest content of antioxidants (tocopherols, tocotrienols, polyphenols and *o*-diphenols), stability and TRAP were found in rapeseed oil. A higher TRAP and stability were observed in crude oil extracts when compared to refined oil extracts (see Table III). A very high correlation was observed between TRAP and stability ( $R = 0.96$ ), tocopherols ( $R = 0.96$ ), polyphenols ( $R = 0.92$ ) and *o*-diphenols ( $R = 0.91$ ). On the other hand, only weak correlation between TRAP and monounsaturated oleic acid content ( $R = 0.61$ ) was found. The results indicate that vegetable oils could be a very important component in arteriosclerosis preventing diets. Antioxidants seem to be the main bioactive components of vegetable oils rather than mono- or polyunsaturated fatty acids.

TABLE I Content of selected fatty acids in various seed oils. Data represent a percentage of total fatty acid content in seed oils and are expressed as means  $\pm$  SD ( $n = 5$ ). The data marked by the same lower case letters in parentheses did not significantly differ within groups of either crude or refined oils (ANOVA,  $p \leq 0.05$ ).

Oil	Fatty acid			
	Stearic 18:0	Oleic 18:1	Linoleic 18:2	Linolenic 18:3
Sunflower <sup>a</sup>	3.7 $\pm$ 0.4 (b)	29.9 $\pm$ 3.1 (b)	59.1 $\pm$ 6.0 (c)	0.1 $\pm$ 0.0 (a)
Sunflower high oleic <sup>a</sup>	3.6 $\pm$ 0.4 (b)	80.3 $\pm$ 8.1 (d)	9.8 $\pm$ 1.0 (a)	0.1 $\pm$ 0.0 (a)
Rapeseed <sup>a</sup>	2.1 $\pm$ 0.2 (a)	55.9 $\pm$ 5.6 (c)	26.5 $\pm$ 2.7 (b)	8.2 $\pm$ 0.9 (c)
Grapeseed	3.8 $\pm$ 0.4 (b)	17.2 $\pm$ 1.8 (a)	67.3 $\pm$ 6.8 (d)	0.4 $\pm$ 0.0 (b)
Sunflower <sup>b</sup>	3.8 $\pm$ 0.4 (b)	30.0 $\pm$ 3.2 (b)	54.0 $\pm$ 5.5 (c)	0.1 $\pm$ 0.0 (a)
Sunflower high oleic <sup>b</sup>	3.4 $\pm$ 0.4 (b)	81.0 $\pm$ 8.2 (d)	10.0 $\pm$ 1.1 (a)	0.1 $\pm$ 0.0 (a)
Rapeseed <sup>b</sup>	2.0 $\pm$ 0.2 (a)	57.0 $\pm$ 5.8 (c)	22.0 $\pm$ 2.3 (b)	10.0 $\pm$ 1.0 (c)
Grapeseed	4.2 $\pm$ 0.4 (b)	17.5 $\pm$ 1.8 (a)	69.5 $\pm$ 7.1 (d)	0.3 $\pm$ 0.0 (b)

<sup>a</sup> crude oils, <sup>b</sup> refined oils

TABLE II Content of selected groups of antioxidants in various seed oils. Data are expressed as means  $\pm$  SD ( $n = 5$ ). The data marked by the same lower case letters in parentheses did not significantly differ within groups of either crude or refined oils (ANOVA,  $p \leq 0.05$ ). Asterisks show significant differences between corresponding values of the crude and refined oils (Student's *t*-test,  $p \leq 0.05$ ).

Oil	Tocotrienols (ppm)	Tocopherols (ppm)	Polyphenols (ppm)	<i>o</i> -Diphenols (ppm)
	Sunflower <sup>a</sup>	165 $\pm$ 15.8 (a)*	179 $\pm$ 16.2 (a)*	2.2 $\pm$ 0.2 (b)
Sunflower high oleic <sup>a</sup>	182 $\pm$ 17.3 (a)	199 $\pm$ 17.3 (a)	2.5 $\pm$ 0.2 (b)	1.6 $\pm$ 0.2 (b)
Rapeseed <sup>a</sup>	311 $\pm$ 29.7 (b)*	249 $\pm$ 3.2 (b)*	4.2 $\pm$ 0.3 (c)*	2.1 $\pm$ 0.2 (c)*
Grapeseed <sup>a</sup>	201 $\pm$ 17.4 (a)	163 $\pm$ 15.8 (a)	0.3 $\pm$ 0.0 (a)	0.5 $\pm$ 0.0 (a)
Sunflower <sup>b</sup>	121 $\pm$ 13.0 (a)	125 $\pm$ 13.1 (a)	1.7 $\pm$ 0.2 (b)	1.1 $\pm$ 0.1 (b)
Sunflower high oleic <sup>b</sup>	169 $\pm$ 15.9 (b)	181 $\pm$ 17.2 (b)	2.3 $\pm$ 0.2 (b)	1.4 $\pm$ 0.1 (b)
Rapeseed <sup>b</sup>	165 $\pm$ 15.8 (b)	179 $\pm$ 16.2 (b)	2.1 $\pm$ 0.2 (b)	1.3 $\pm$ 0.1 (b)
Grapeseed <sup>b</sup>	195 $\pm$ 17.2 (c)	152 $\pm$ 14.9 (ab)	0.3 $\pm$ 0.0 (a)	0.4 $\pm$ 0.0 (a)

<sup>a</sup> crude oils, <sup>b</sup> refined oils

**Keywords:** antioxidants; polyphenols; seed oils; stability; fatty acids

## Acknowledgements

The study was supported by grant No. B6004204 of GAAVCR.

TABLE III Total radical-trapping antioxidant potential and stability of various seed oils. Data are expressed as means  $\pm$  SD ( $n = 5$ ). The data marked by the same lower case letters in parentheses did not significantly differ within groups of either crude or refined oils (ANOVA,  $p \leq 0.05$ ). Asterisks show significant differences between corresponding values of the crude and refined oils (Student's  $t$ -test,  $p \leq 0.05$ ).

Oil	TRAP (nmol/ml)	Stability (hours)
Sunflower*	319 $\pm$ 47 (b)*	3.1 $\pm$ 0.3 (a)*
Sunflower high oleic*	389 $\pm$ 75 (b)	3.3 $\pm$ 0.3 (a)
Rapeseed*	556 $\pm$ 108 (c)*	5.2 $\pm$ 0.5 (b)*
Grapeseed*	215 $\pm$ 31 (a)	2.6 $\pm$ 0.3 (a)
Sunflower <sup>b</sup>	201 $\pm$ 33 (a)	2.5 $\pm$ 0.2 (a)
Sunflower high oleic <sup>b</sup>	321 $\pm$ 63 (b)	3.1 $\pm$ 0.3 (b)
Rapeseed <sup>b</sup>	324 $\pm$ 39 (b)	3.1 $\pm$ 0.3 (b)
Grapeseed <sup>b</sup>	190 $\pm$ 30 (a)	2.5 $\pm$ 0.2 (a)

\* crude oils, <sup>b</sup> refined oils

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## Bioavailability of Antioxidant Compounds Content in Raw and Cooked Cherry Tomato in *in vitro*, *ex-vivo* and *in vivo* Models

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Epidemiological studies have underlined that the intake of tomato and tomato products (sauce, paste) reduces the incidence of chronic-degenerative diseases, due to their high antioxidant content<sup>(1,2)</sup>.

The aim of our investigation was to evaluate the effect of domestic cooking on the bioavailability in humans of both carotenoids and polyphenols after the administration of a test meal containing cherry tomato (CT). Moreover, we have evaluated antioxidant incorporation in LDL and LDL resistance to oxidation after administration of raw CT. Finally, cellular uptake of CT polyphenols was studied incubating human colon cancer line CaCO2 with polyphenol extract by raw CT.

Five healthy subjects aged from 21-34 years were recruited to take part in the study on bioavailability. On the three days prior to the study the volunteers were told to avoid tomato and tomato products and to consume a diet low in carotenoids and polyphenols. On the day of the study subjects arrived fasted and base-line blood samples were taken. Each subject consumed 500 g of raw CT together with 70 g of pasta, 25 g of extra virgin

olive oil and not more than 50 g of bread. Blood was collected also at different time intervals (2, 4, 6, 8 and 24 h). The same study design was repeated one week later administering CT cooked for 15 min at 100°C. Plasma total cholesterol and triglycerides were measured using commercial kits. Plasma levels and LDL incorporation of both carotenoids and polyphenols and polyphenol cellular uptake were detected by HPLC techniques<sup>(3,4,5)</sup>.

The results of the human study showed that plasma levels of triglycerides in plasma 8 h after consumption of cooked CT were significantly ( $P < 0.05$ ) different from the baseline (data not shown), while plasma levels of lycopene and  $\beta$ -carotene were not significantly increased after administration of both raw and cooked CT (data not shown). Naringenin and chlorogenic acid maximum concentrations were reached 6 h after consumption of cooked CT and were significantly higher ( $P < 0.05$ ) than those observed after administration of raw CT (figures 1 and 2). Fig 3 shows the time - dependent lycopene and  $\beta$ -carotene LDL incorporation and the corresponding decrement in MDA production in stressed LDL after administration of raw cherry tomato.

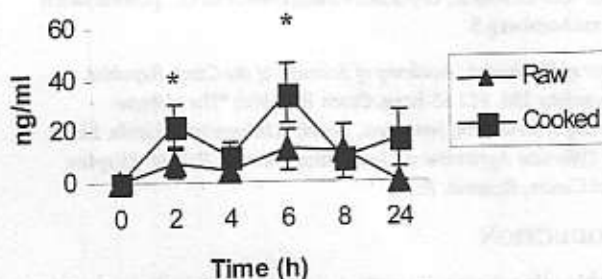


FIGURE 1 Change in concentrations of naringenin in human plasma after consumption of fresh and cooked tomato meals. Values are means of five subjects and bars indicate standard deviation. \*significantly different vs time 0  $P < 0.05$  (Anova test).

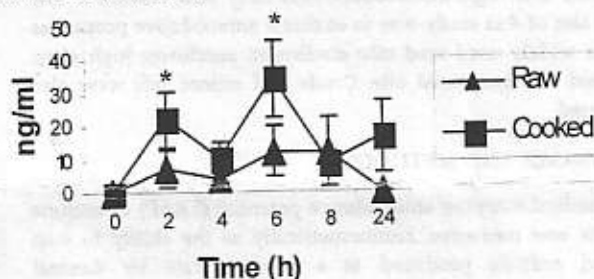


FIGURE 2 Change in concentrations of chlorogenic acid in human plasma after consumption of fresh and cooked tomato meals. Values are means of five subjects and bars indicate standard deviation. \*significantly different vs time 0  $P < 0.05$  (Anova test).

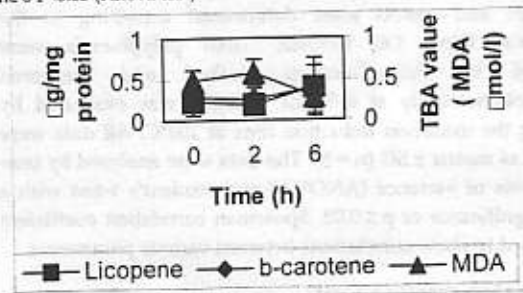


FIGURE 3 Incorporation of lycopene and  $\beta$ -carotene in LDL and their effect on oxidation of LDL after consumption of raw cherry tomato.