Use of red chilli pepper as natural antioxidant for improving the oxidative stability of edible oils

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INTRODUCTION

Olive oil is an integral ingredient of the Mediterranean diet and an example of a functional food, due to various components that may contribute to its health benefits. The most important factor determining the shelf life of olive oil is its oxidative stability: oxidation of lipids not only produces rancid odors, unpleasant flavors and discoloration, but it can also decrease the nutritional quality and safety of olive oil.
Powdered red chilli pepper is widely used as a natural antioxidant ingredient to retard or prevent lipid oxidation, to preserve the quality and to extend the shelf-life of food products, thanks to its high content of carotenoids and polyphenolic compounds and to its content of capsaicinoids, responsible for its characteristic hot taste.

MATERIALS AND METHODS

A few grams of powdered red chilli pepper from different cultivars were added to three edible oils (olive oil, extra-virgin olive oil and seed oil).
Their oxidative stability, at the beginning and during storage, was investigated by accelerating the oxidation process using the Oxitest reactor (VELP Scientifica; Italy) (Figure 1).
The Oxitest technique is based on the change in the absolute oxygen pressure in a closed and thermostatic chamber, assumed as the oxygen uptake by reactive substances. The oxidation curve produced by the Oxitest is characterized by an Induction Period (IP) as the time required to reach an end point of oxidation corresponding to either a level of detectable rancidity or a sudden change in the rate of oxidation (Figure 2).
The working conditions of the Oxitest are shown in Table 1.
This study was developed in 3 phases.

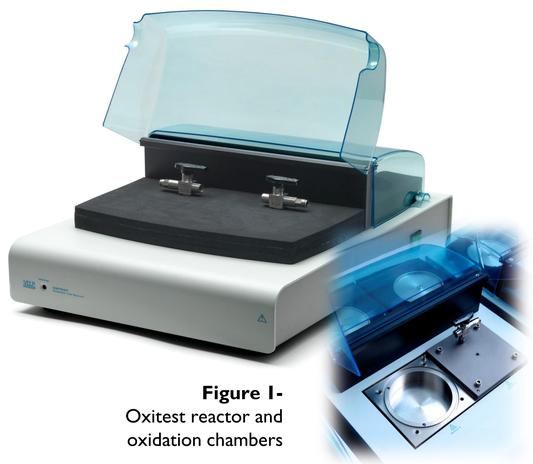

Figure 1- Oxitest reactor and oxidation chambers

Temperature: 90 °C
Oxygen pressure: 6 bar
10 g of oil sample distributed in each sample holder of the reaction chambers
Time of storage: T1= 1 month T2= 3 months

Table 1- Oxitest working conditions

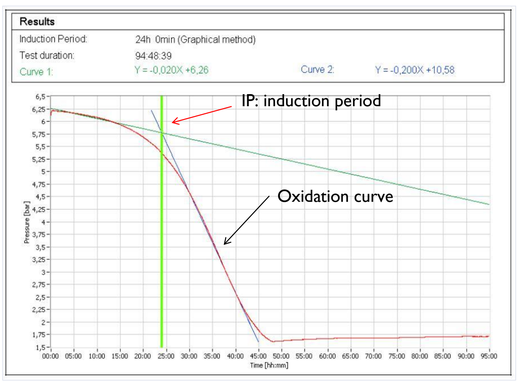

Figure 2 - Typical oxidation curve

PHASE 1: CHILLI PEPPER ADDED TO 3 EDIBLE OILS

A few grams of powdered red chilli pepper (sweet piquancy) were added to three types of edible oil (olive VO, extra-virgin olive EVO, and seed oil SO) tested at time 0 and after 1 month storage.
For each type of oil, 2 or 3 oil samples of different brands were analyzed. Quantity of chilli pepper: 1% (1.5 g in 150 ml).

The addition of powdered red chilli pepper to the oils showed an extension of their stability (Table 2). The effect was different depending on the type of oil: the effect on olive oil was more evident than that on extra-virgin oil and seed oil. At T0 significant variations were observed on the VO3 sample only. At T1 some samples (EVO2, VO2 e SO1), that loose stability if unaltered, increase their stability with the addition of chilli powder.

t-test at T0	Sample	T0	RSD %	T1	RSD %	t-test T0, T1
p= 0.577	EVO 1	81:22	1.5	87:11	5.0	*p= 0.011
	EVO 1 + pep	80:30	5.2	80:38	3.8	p= 0.954
p= 0.233	EVO 2	81:11	2.2	76:49	4.7	*p= 0.033
	EVO 2 + pep	79:06	7.2	74:04	5.7	p= 0.135
p= 0.134	VO 1	29:48	3.1	29:07	2.2	p= 0.347
	VO 1 + pep	32:05	5.9	32:39	7.4	p= 0.768
p= 0.076	VO 2	30:48	0.0	29:39	2.2	*p= 0.013
	VO 2 + pep	32:52	5.8	31:31	5.6	p= 0.246
*p= 0.047	VO 3	26:59	4.8	24:56	7.2	p= 0.182
	VO 3 + pep	29:11	1.5	28:42	4.7	p= 0.578
p= 0.415	SO 1	21:14	6.4	19:48	4.7	*p= 0.056
	SO 1 + pep	20:32	6.8	20:14	5.2	p= 0.747
p= 0.447	SO 2	20:11	10.3	19:56	3.9	p= 0.838
	SO 2 + pep	21:19	5.2	21:13	2.9	p= 0.879
p= 0.278	SO 3	21:25	7.4	20:36	6.8	p= 0.842
	SO 3 + pep	21:46	6.7	21:06	5.9	p= 0.509

Table 2 - Results table. IP values average (hh:mm)
RSD % = Relative standard deviation
*p<0.05, significative difference between the two means

PHASE 2: 3 TYPES OF CHILLI POWDER IN EVO

Three chilli powders with different levels of piquancy (sweet, medium and hot) were added to EVO1 and analyzed at T0, T1 and T2 (Table 3).
Of the three powders tested, the strongest effect was observed with the less piquant one. Therefore, the antioxidant effect could not be attributed to the capsaicinoids, responsible for piquancy, but to the presence of other antioxidant phenolics.

Sample	Description	Scoville Units
Pep. 1	Sweet red chilli	300
Pep. 2	Medium red chilli	8600
Pep. 3	Hot red chilli	16000

Table 3. Piquancy values (Scoville Units) of the three chilli powders.

This behavior was also confirmed by FRAP assay on chilli powders, showing the highest antioxidant power in the less piquant chilli pepper.
Figure 3 shows that the addition of powdered chilli pepper in extravergin olive oil increases its stability during storage. Moreover, the antioxidant power is not related to piquancy.
In order to confirm the Oxitest results, the FRAP assay was performed directly on the powdered chilli peppers.
Figure 4 represents the excellent correlation between the results obtained using the two methods.

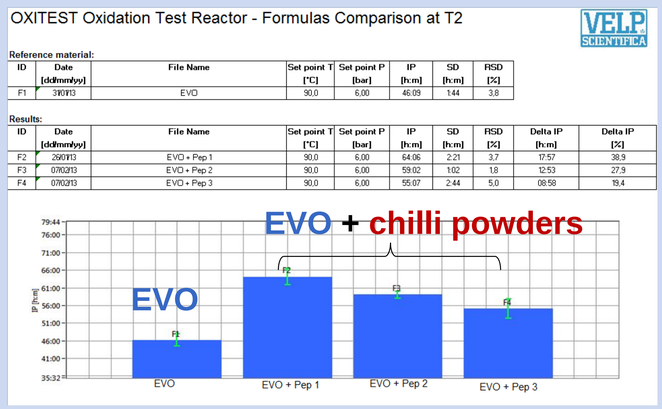

Figure 3 - Formulas comparison between EVO and EVO+chilli powders at T2

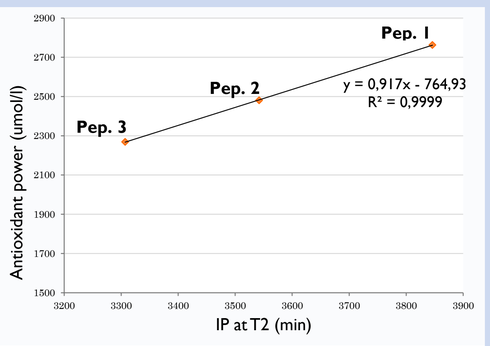

Figure 4 - Linear correlation between antioxidant power of chilli powders and Oxitest results on EVO+chilli powders at T2

PHASE 3: DOSE-EFFECT TEST

Different quantities of sweet chilli powder were added to VO and EVO oils:
0 %; 0.2%; 1.0%; 3,3% in VO
0 %; 0.1%; 0.3%; 1% in EVO
Oxitest tests were performed during the shelf-life of the oils, at T1 and T2.

An evident dependence between oil stability and concentration of chilli powder was found mostly in olive oil (VO). Although a proportional correlation wasn't found, the threshold value was observed at 1%: the results of VO samples with 1% chilli are the same as those with 3.3% (Figure 5).
Even in long term storage, extra-virgin olive oil doesn't show a significant difference between 1 % and lower concentrations, probably due to its natural higher oxidative stability related to its high content of natural polyphenols (Figure 6).

The data obtained confirm the observations made in the previous phase1: the protective effect of powdered red chilli pepper is more evident on oil samples which by nature have a low stability.

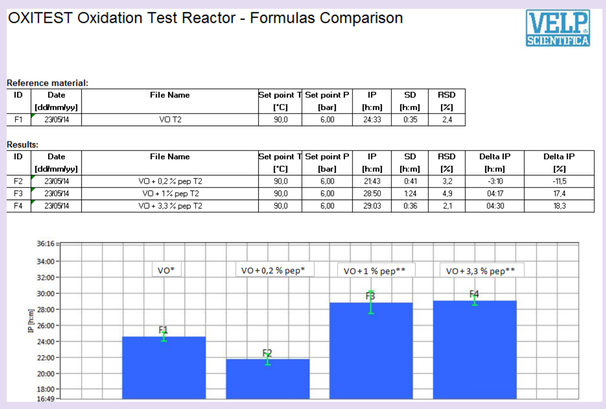

Figure 5 - Oxitest Dose-effect results on samples VO at T2.
One-way ANOVA: significant difference between samples VO-0.2% pep. and 1% - 3.3% pep. ($p<0.05$).

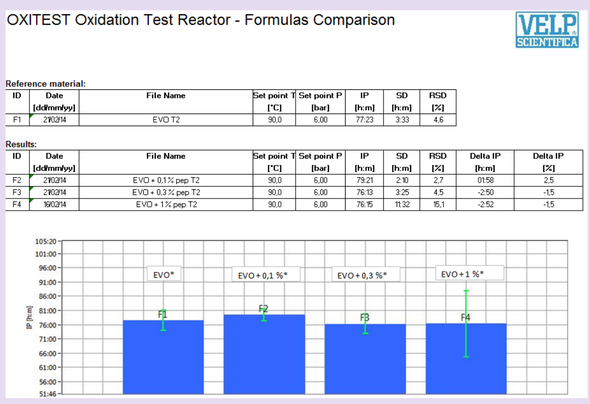

Figure 6 - Oxitest Dose-effect results on samples EVO at T2.
One-way ANOVA: no significant difference between EVO samples ($p>0.05$)

CONCLUSIONS

- The addition of chilli powder to oil determines in many cases a higher resistance against oxidation.
- The protective effect of powdered red chilli pepper is more evident on oil samples which by nature have a low oxidation stability. In contrast, more stable oils (i.e. EVO) do not benefit from the addition of chilli powder during storage.
- The effect depends on the type of chilli pepper and is not related to its hotness, but to its antioxidant power.
- From the Dose-effect test a threshold concentration has been defined for VO oil. At a concentration of below 1% differences were not observed compared to the control sample, similarly, at higher concentrations the beneficial effects were not proportional to the higher concentration.
- The Oxitest accelerated oxidation reactor is a valid instrument for calculating the Induction Period of oils and evaluating their resistance to oxidation.

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