COMPARATIVE STUDY OF OXIDATION IN CANNED FOODS WITH A COMBINATION OF VEGETABLES AND COVERING OILS

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ABSTRACT

The effects of sunflower (SFO), extra-virgin olive (EVO), and soybean oils (SBO), in combination with canned aubergins and dried tomatoes were studied during an accelerated shelf-life trial. Hydrolytic and oxidative quality parameters was determined and a sensorial test was run. For both canned vegetables, the SBO showed greater resistance to the oxidation at the end of the shelf-life trial. The SBO in both vegetables yielded similar results for peroxide formation, whereas a reduced formation of secondary oxidation products was observed in aubergins. The results highlighted a higher oxidation stability of canned vegetables in SBO and EVO than those in SFO. The sensorial test underlined differences between the oils, in aubergins and dried tomatoes, after 30 days of accelerated storage (corresponding to the sell-by date). Flavour and texture were judged better for vegetables in SBO.

- Keywords: canned vegetables, extra-virgin olive oil, oxidation, preservation, soybean oil, sunflower oil -

1. INTRODUCTION

Canned foods are products packed and hermetically sealed in metal (tin, aluminum), glass, or polymer containers that are thermally treated to destroy spoiling microorganisms and their enzymes with the aim to prolong the shelf-life. (LEISTNER, 1992). Moreover, the process of preparation and preservation could increase the quality of vegetable products because of the presence of added oils as cover liquids (LEISTNER, 1992). In canned vegetables: i) the covering oil promotes anaerobic conditions (i.e., less than 2% oxygen); ii) an adequate blanching treatment reduces numbers of contaminating microorganisms, inactivates enzymes, modifies texture, preserves color, flavor, and nutritional value, and removes trapped air; and iii) pasteurization guarantees commercial sterility (REYES DE CORCUERA *et al.*, 2004; BAIANO *et al.*, 2005a). In the food industry, virgin and extra-virgin olive oil, olive oil, seed oils, or various oil blends, are used as covering oils to prepare preserved vegetables. The quality of canned vegetables in-oil depends on the complex interactions between traits of the vegetables and those of the covering oils. During storage, many bioactive molecules migrate from the vegetable to the oil and vice versa, in a dynamic equilibrium that depends on the characteristics (e.g., chemical composition, structure, size, and shape) of vegetables and oils as well as on the technology used for preparation and storage (LUCCHETTI *et al.*, 2011). Spices and aromatic herbs, generally used as flavor enhancers in preparation of canned vegetables, also contribute to the quality of the canned product. They contain substances with documented antimicrobial, antioxidant and anti-inflammatory activities (GAMBACORTA *et al.*, 2007).

The shelf-life of in-oil canned vegetables depends on the quality of the vegetable and the covering oil and its composition (BAIANO *et al.*, 2005a). During processing and over the time, vegetables and oils undergo modifications because of mechanical and thermal degradation and hydrolytic and oxidative degradation (affecting the quality of oil and preserved food) (DE GIORGI *et al.*, 2000; BAIANO *et al.*, 2005b). Some studies have examined the oxidative and hydrolytic reactions that occur in the covering oil, and on the effects of the use of different oils as a covering medium on the canned vegetables preservation (LEISTNER, 1992; BAIANO *et al.*, 2005a; BAIANO *et al.*, 2005b; BAIANO *et al.*, 2005c).

The aim of the present paper was to compare the effects of the combination of different vegetables and covering oils in canned foods. Sunflower oil (SFO), extra-virgin olive (EVO) and soybean oil (SBO) in combination with canned aubergins and dried tomatoes were studied. The quality of covering oils was studied to verify the effect of these combinations during storage. Hydrolytic and oxidative quality parameters were measured together with sensory analysis. SFO was examined because of its wide use in the production of canned foods, EVO was examined because of its sensorial and nutritional properties, and SBO was examined for its nutritional value, widespread use, and low cost.

Moreover, the effects of aromatic herbs and spices (ingredients included in the recipes for canned vegetables) on oxidative degradation of the three oils were examined as a separate test on pure oils. The herbs and spices in the recipe were: i) garlic, rich in flavonoids and sulfur-containing compounds (LEELARUNGRAYUB *et al.*, 2006); ii) chili pepper, containing allicin, carotenoids, ascorbic acid, and phenolic compounds (SUHAJ, 2006); iii) oregano, containing various flavonoids (KYOJI *et al.* 2006); and iv) mint, rich in polyphenols and flavonoids (KANATT *et al.*, 2007; PADMINI *et al.*, 2008).

2. MATERIALS AND METHODS

Both commercial in-oil canned aubergins and dried tomatoes were prepared according to traditional recipes with three different vegetable oils (SFO, EVO, and SBO). The oil samples were provided by Vizzino "Orto Buono," Minervino di Lecce, Italy. All canned products were produced on the same day and analysed, at time zero (T0) and 15 days after processing (T1).

2.1. Preparation of in-oil canned vegetables

The canned vegetables used were aubergins in SFO (AUSFO), EVO (AUEVO), or SBO (AUSBO), and dried tomatoes in SFO (DTSFO), EVO (DTEVO), or SBO (DTSBO). Traditional recipes included the addition of chili pepper (0.001 g kg^{-1} of total product), oregano (0.001 g kg^{-1}), mint (0.001 g kg^{-1}), and garlic (0.004 g kg^{-1}) for canned aubergins and mint (0.001 g kg^{-1}) and garlic (0.004 g kg^{-1}) for canned sun-dried tomatoes. A batch of 150 kg of 1 cm slices of peeled aubergins were previously treated with coarse salt (20% w/w), then drained and washed with water and centrifuged. Then the slices of aubergins dehydrated were mixed with powdered herbs and spice (chili pepper, garlic, oregano, and mint) and a dose of 280g was put in transparent glass vessels, wrapped with metal caps. Vessels were then filled in the three considered oils (vegetables 65%, oil 33%, w/w) and hermetically sealed. A batch of 150 kg of dried tomatoes were blanched in boiling white vinegar for 30 seconds, then drained and dried, mixed with aromatic herbs (garlic and mint). Transparent glass vessels were filled with 280g of tomatoes and in the three considered oils (vegetables 65%, oil 33%, w/w), and hermetically sealed. The canned samples were pasteurized at 90°C for 40 minutes, and then quickly cooled to room temperature.

2.2. Aromatic herbs and spices added to oils

A case study (separate test on pure oils with herbs and spices) was conducted to investigate the efficacy as antioxidant, and to verify the protective effects of aromatic herbs and spices present as ingredients in the traditional recipes for considered canned foods. For this purpose SFO, EVO, and SBO, used in canned food preparation, were prepared with the different aromatic herbs and spice used in the recipe: chili pepper, garlic, oregano and mint (to investigate the effect of each single herb or spice); a mixture of mint and garlic (to simulate the dried tomatoes recipe); and a mixture of all the aromatic herbs and spice (to simulate the aubergins recipe). The spice and aromatic herb contents were chosen to simulate the same concentrations used in the recipes for canned vegetables in oils. The samples to analyze were: i) SFO, EVO, or SBO, with added garlic (0.1 g/100mL of oil); ii) SFO, EVO, or SBO with added chili pepper (0.03 g/100mL); iii) SFO, EVO, or SBO with added oregano (0.03 g/100mL); iv) SFO, EVO, or SBO with added mint (0.03 g/100mL); v) SFO, EVO, or SBO with added mint and garlic (0.03 g/100mL and 0.1 g/100mL, respectively); and SFO, EVO, or SBO with all aromatic herbs and spice under consideration added.

The samples were subjected to the same Accelerated Shelf-Life Test (ASLT) for canned vegetables and the extent of the hydrolytic and oxidative degradation of oils was determined by assessing peroxide numbers and *p*-anisidine values.

2.3. Accelerated Shelf-Life Test (ASLT)

To evaluate the shelf-life of the canned vegetables and of the pure oils with added herbs and spices, an accelerated shelf life test (ASLT), in which the storing of canned foods for 1 day at 55 °C corresponds to 18 days at room temperature (20°C), was performed (ROBERTSON, 1993; KILCAST, 2000; MAN, 2015). Accelerated aging was defined according to a common industrial method based on the Arrhenius equation, which defines the relationship between product shelf-life and the temperature (ROBERTSON, 1999; GIMÉNEZ *et al.*, 2012; MARCONI *et al.*, 2014;). The glass vessels with the vegetables canned in different covering oils were kept in a laboratory oven (Thermo Fisher Scientific, Milan, Italy) at 55°C for 10, 20, 30, and 40 days, which corresponds to 6 (T1), 12 (T2), 18 (T3) and 24 (T4) months at room temperature, respectively. The vegetable oils were then subjected to chemical and sensorial analysis.

2.4. Chemical analyses

The quality of the crude oils and the ongoing hydrolysis and oxidation of the covering oils were monitored by measurements of the acidity, expressed as g of oleic acid per 100 g of oil; peroxide values, expressed as milliequivalents (mEq) of active oxygen per kg of oil (E. U, 1348/2013), *p*-anisidine values (AOCS, 1998). The hydrolytic and oxidative parameters were determined by conventional methods of analysis. After separation from the vegetable matrices, the covering oil samples were filtered on anhydrous sodium sulfate and analysed after different storage times.

2.5. Sensory evaluation

Sensorial test was conducted to evaluate the palatability of the canned vegetables preserved in different oils at T0 and T3 (at the sell by date of canned food). Nine trained panelists (six women and three men), 30–50 years, evaluated the canned vegetables using the quantitative descriptive analysis technique.

The panelists were trained in 10 sessions, using standards and similar food products, to identify and determine descriptors relating to appearance, taste, and texture. The terms and the corresponding definitions (Table 1) were available to the panelists during all sessions. The evaluation of the canned vegetables was performed over two days in two sessions. Canned vegetables were served at room temperature. Crackers were used as a carrier for tasting. Different canned vegetables, in the different covering oils, were evaluated for sensory attributes, which included appearance (color), flavor (rancid, salty, and bitter), and texture (hardness and chewiness). A 10-point

Table 1 - Definition of physical and flavor descriptors used in the quantitative descriptive analysis.

Descriptor	Definition
Physical	
Color	Intensity of vegetable color.
Hardness	By steadily compressing the vegetable between the molars, the force required for compression.
Chewiness	The lenght of the time required to masticate the vegetable to a state of swallowing.
Flavour	
Rancidness	Unpleasant, stale smell or taste proper of oils and fats.
Saltiness	Taste of salt perceptible on the tip of the tongue and on the sides around it.
Bitterness	Harsh, disagreeably acrid taste.

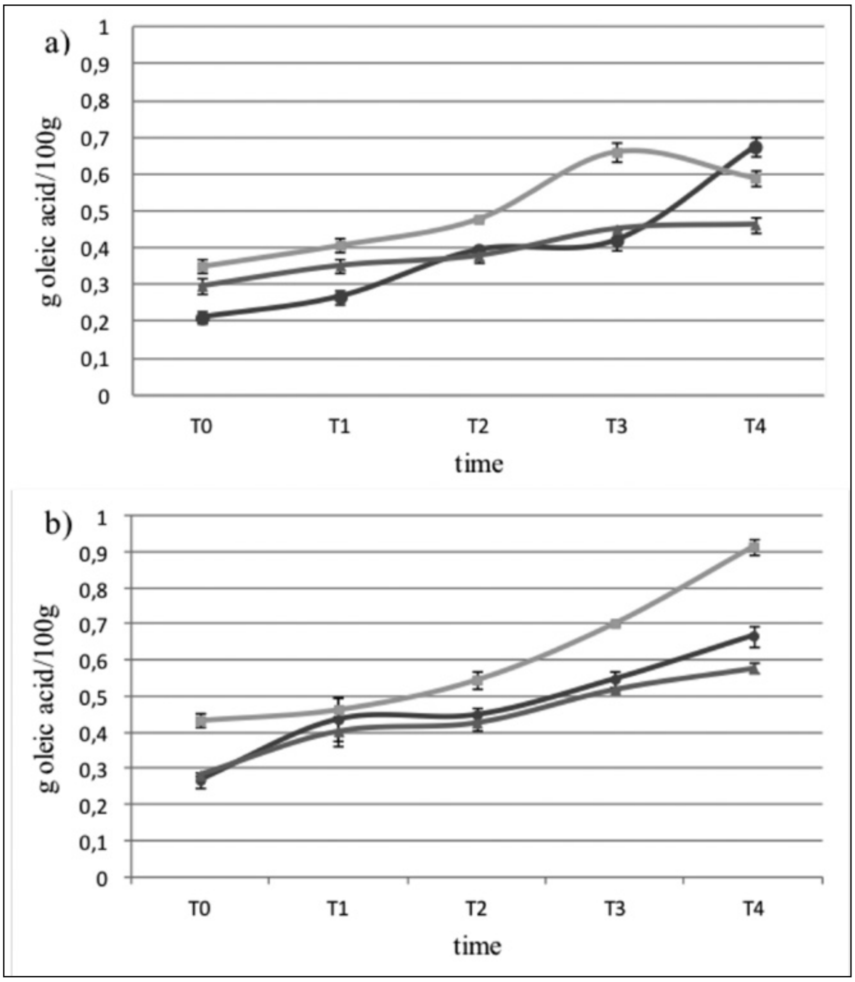

Fig. 1 - Free acidity of covering oils in canned aubergins (a) and in canned dried tomatoes (b) as a function of storage.
n = 6; bars in the figures represent standard deviation values; EVO = extra-virgin olive oil.
T0: 0 days; T1: 10 days; T2: 20 days; T3: 30 days; T4: 40 days

scale (from 0 to 9) was used where color (0 = extremely light to 9 = extremely dark); hardness (0 = extremely soft to 9 = extremely hard); chewiness (0 = none to 9 = extremely gummy); and rancidity, saltiness, and bitterness (0 = none to 9 = extremely strong) were assessed.

2.6. Statistical analysis

All data were analysed using SigmaStat (version 11, Jandel Scientific, San Rafael, CA) software to perform the appropriate statistical tests. Comparisons of the different vegetable and oil samples were made using one-way repeated measures analysis of variance, and the results obtained were further analysed using the Holm-Sidak test.

Each canned vegetable sample was produced in duplicate and all chemical analyses were performed in triplicate. Values were considered significantly different at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Oils

The quality parameters (free acidity, peroxide values, *p*-anisidine values, and fatty acid composition) of the three oils, employed as covering oils in the preparation of canned vegetables, are discussed. The acidity values were lower than 0.3% in all samples (0.11, 0.28, and 0.15 g oleic acid/100g for SFO, EVO, and SBO, respectively), which confirms low levels of hydrolytic activity in the oils comparable with cold pressed and virgin oils (CODEX-STAN 210-1999; EC, 1513/2001). The peroxide values were low for all oils (4.22, 13.55, and 2.93 meqO_2/kg, for SFO, EVO, and SBO, respectively), even if comparatively high in EVO (a value that was below the legal limits (EEC, 2568/91). The *p*-anisidine values in the three oils were low according to GUPTA (2005) and LIST *et al.* (1974), and the lowest value was observed for SBO (6.39, 6.42, and 1.95 for SFO, EVO, and SBO, respectively).

3.2. Preserved vegetables

The free acidity values of the covering oils for canned aubergins and dried tomatoes during the ASLT are reported in Fig. 1. Free Fatty Acids (FFA) are formed by chemical or enzymatic hydrolysis of triglycerides and may get promoted by the reaction of oil with moisture (naturally present in vegetables), FFAs content is an important measure of alteration for oils. In all considered sample the free acidity increased during the accelerated aging.

For canned aubergins (Fig. 1a), the FFAs percentage increased from 0.21 to 0.68% for SFO, from 0.35 to 0.60% for EVO, and from 0.30 to 0.46% for SBO.

For canned dried tomatoes (Fig. 1b) and the three different covering oils used, the free acidity increased during the ASLT. The FFAs contents increased from 0.27 to 0.67% for SFO, from 0.43 to 0.92% for EVO, and from 0.28 to 0.58% for SBO. Despite contact with the moist vegetable matrix, the acidity values were satisfactory. After 30 days of ASLT (18 months of conventional storage at room temperature), the changes in acidity for both aubergins and tomatoes were less than 1%. For aubergins, the acidity value for EVO was under the maximum limit for extra-virgin olive oil (EU, 61/2011), and for tomatoes, the value exceeded the maximum legal limit after 30 days of accelerated aging, anyway after the sell-by date of the canned product.

Fig. 2 shows the peroxide values and the *p*-anisidine numbers of the different covering oils for the canned aubergins (Fig. 2a) and dried tomatoes (Fig. 2b), respectively. The peroxide value indicates the level of rancidity that normally occurs in oils because of progressive unsaturated fatty acid oxidation. For canned aubergins (Fig. 2a), at T0, which corresponds to the fresh product, the peroxide values were unaltered or, for SBO, slightly increased with respect to the pure oils used as covering medium. The peroxide values for the product at the beginning of the shelf-life trial was similar for the canned dried tomato covering oils, nearly the same for SFO and EVO, and slightly increased for SBO as compared to the peroxide values of the pure oils (Fig. 2b). In all preserved vegetables, the peroxide values decreased after the beginning of the shelf-life trial while peroxide compounds were progressively decomposed into secondary oxidation products (aldehydes and ketones and polymers) which corresponds in an increase of *p*-anisidine value. The *p*-anisidine value reveals the presence of secondary oxidation products. In canned aubergins, the peroxides were reduced to one-half the initial value at the end of ASLT (Fig. 2a); in canned dried tomatoes, the decrease in peroxides was more rapid and was about 1 mEq O_2/kg after 40 days of accelerated aging (Fig. 2b).

As shown in Fig. 2, the *p*-anisidine values of the oils used for covering the preserved vegeta-

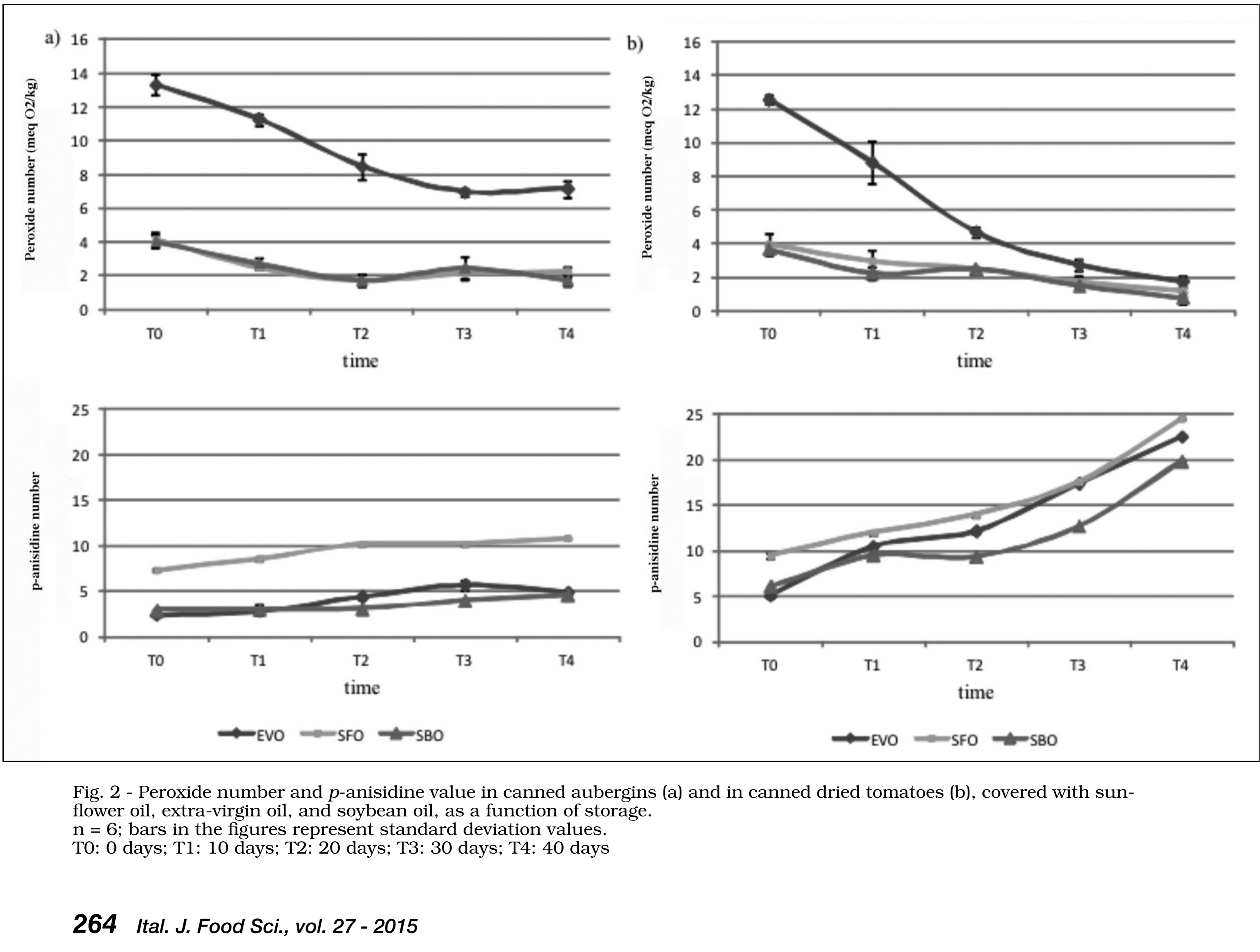

Fig. 2 - Peroxide number and *p*-anisidine value in canned aubergins (a) and in canned dried tomatoes (b), covered with sunflower oil, extra-virgin oil, and soybean oil, as a function of storage.
n = 6; bars in the figures represent standard deviation values.
T0: 0 days; T1: 10 days; T2: 20 days; T3: 30 days; T4: 40 days

bles showed a progressive increase during the ASLT.

For canned aubergins (Fig. 2a), *p*-anisidine values for EVO and SBO covering oils were significantly lower ($p < 0.05$) than that for SFO for the period of storage, and the decomposition of the hydroperoxides proceeded at a greater rate in SFO than in the EVO or SBO. As compared with the *p*-anisidine values found for EVO, the *p*-anisidine values of soybean oil were lower from two to four weeks of accelerated storage.

SBO had the lowest oxidative rancidity during the ASLT. Comparing the results of the two types of canned vegetables, the *p*-anisidine values of the covering oils for dried tomatoes were higher than those for aubergins during ASLT. However, as in canned aubergins, the *p*-anisidine numbers of tomatoes in SBO were significantly lower than those of the other oils considered at the sell-by date (Fig. 2b).

Since the data underlined the lowest content of hydroperoxides and the simultaneous lowest value of *p*-anisidine for aubergins and dried tomatoes in SBO and since the SBO showed the lowest value of free acidity, we may conclude that SBO has appreciable characteristics of stability to oxidation as covering oil in canned vegetables. A high stability of SBO under the similar conditions of storage was underlined by WARNER *et al.* (1989) in a previous study.

Dried tomatoes exhibited a higher index of secondary oxidation (*p*-anisidine value) than aubergins. At the sell-by date (18 months, 30 days of accelerated aging), the *p*-anisidine value of canned dried tomatoes was 12.66 ± 0.02, 17.38 ± 0.10, and 17.53 ± 0.10 for SBO, EVO, and SFO respectively. Conversely, in aubergins, the highest *p*-anisidine value at the sell-by date was 10.80 ± 0.13 in SFO. Differences in oxidation of covering oils for aubergins and dried tomatoes could justify consideration of the additive protective effects of antioxidant compounds present in aubergins (such as phenolic compounds, flavonoids, ascorbic acid, and vitamin A) and in dried tomatoes (lycopene, ascorbic acid, phenolic, flavonoids, and vitamin E) (HUNG and DUY, 2012), and the antioxidant effects of aromatic herbs and spices added (chili pepper, garlic, oregano, and mint).

Aubergin is one of the most active vegetables in its free radical scavenging capacity because of its phenolic constituents (JUNG *et al.*, 2011; HUNG and DUY, 2012). Considering aromatic herbs and spices, the antioxidant effects of the pungent component of chili pepper, capsaicin, has been documented in previous studies (REYES-ESCOGIDO *et al.*, 2011). HENDERSON and HENDERSON (1992) observed that the oxidation of oleic acid at cooking temperatures was inhibited by the presence of capsaicin. In addition, capsaicin is reported to inhibit lipid peroxidation (SALIMATH *et al.*, 1986; PULLA REDDY and LOKESH, 1992; ASAI *et al.*, 1999; HENDERSON *et al.*, 1999; OKADA and OKAJIMA, 2001; KOGURE *et al.*, 2002). Garlic has been reported to reduce free radical-induced oxidative damage in animal and human models. Extensive studies performed on garlic extracts (*Allium sativum* L.) highlighted the presence of two main classes of antioxidants: flavonoids and sulfur-containing compounds (LEELARUNGRAYUB *et al.*, 2006). The four main garlic antioxidant compounds are alliin, allyl cysteine, allyl disulfide, and allicin (BENKEBLIA, 2005; EL SHENAWY *et al.*, 2008). Oregano (*Origanum majorana*) is one of the aromatic herbs known to possess antioxidant compounds such as rosmarinic acid, caffeic acid, and various flavonoids. Oregano extracts have shown a pronounced effect on stabilizing lipids against autoxidation (KYOJI *et al.* 2006). The effectiveness of mint, a common aromatic herb, as a natural antioxidant is widely documented (KANATT *et al.*, 2007; PADMINI *et al.*, 2008; SAZHINA *et al.*, 2011). For canned aubergins, the antioxidant capacity arises from the typical antioxidant compounds of the vegetable and of garlic, mint, oregano and chili pepper; for preserved dried tomatoes, the antioxidant capacity arises from the vegetable and garlic and mint. The antioxidant capacity of aubergin is higher than that of dried tomato (WU *et al.*, 2004). The aromatic herbs added to canned dried tomatoes were mint and garlic, and the additive effect of these two herbs may be lower than that of the canned aubergins and the herbs and spices used for it. Different results for the two canned foods may have been caused by their different antioxidant properties and the different added aromatic herbs and spices.

To confirm the above hypothesis, aromatic herbs and spices were added to the pure oils used as packing oils for the vegetables considered. Each oil used for each vegetable had different aromatic herbs and spices in the recipe (chili pepper, garlic, oregano, and mint), a mixture of mint and garlic, or a mixture of all aromatic herbs and spices together, and was analysed for peroxide numbers and *p*-anisidine values. The results are reported in Figs. 3, 4 and 5.

The peroxide numbers and *p*-anisidine values of the three oils considered were influenced by the added aromatic herbs and spices. In particular, during the ASLT, the oil samples with added garlic, with added mint and garlic, and with all herbs and spices added presented lower values of the oxidation parameters. In SFO, a higher peroxide number was observed in the sample without spices and herbs, whereas chili pepper, oregano, and mint, showed an antagonistic effect on peroxide formation. For *p*-anisidine, lower values were observed in oil with added garlic and in oil with all herbs and spices added, whereas the oil with added mint and garlic had higher values; however, these values were lower than those found with other added herbs and spices.

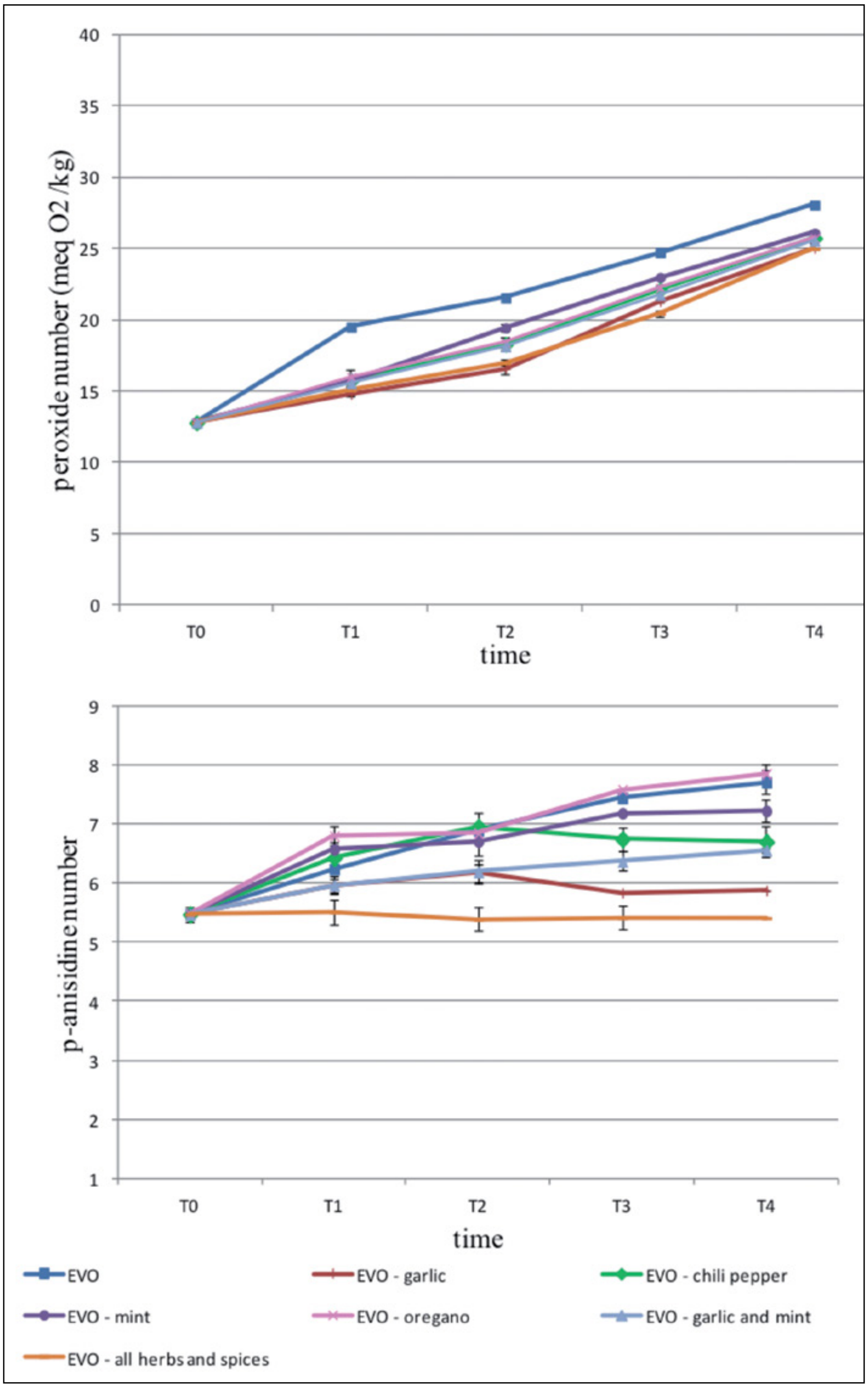

Fig. 3 - Peroxide number and p-anisidine value of extra-virgin olive oil (a), sunflower oil (b), and soybean oil (c), without herbs and spices and with different herbs and spices, as a function of storage.
n = 6; bars in the figures represent standard deviation values.
EVO = extra-virgin olive oil.
T0: 0 days; T1: 10 days; T2: 20 days; T3: 30 days; T4: 40 days.

A similar result was found for EVO where a low peroxide number was observed in oil samples with added garlic, and with all herbs and spices added. Samples with added mint and garlic had the same results as EVO with added oregano. The lower *p*-anisidine value for EVO was observed with added garlic, added mint and garlic, and when all herbs and spices were added. For SBO, each of the aromatic herbs and spices influenced the peroxide number and *p*-anisidine value. A higher protective effect was found for added garlic and for samples with all herbs and spices added. The oil with mint added had a *p*-anisidine value similar to the sample with add-

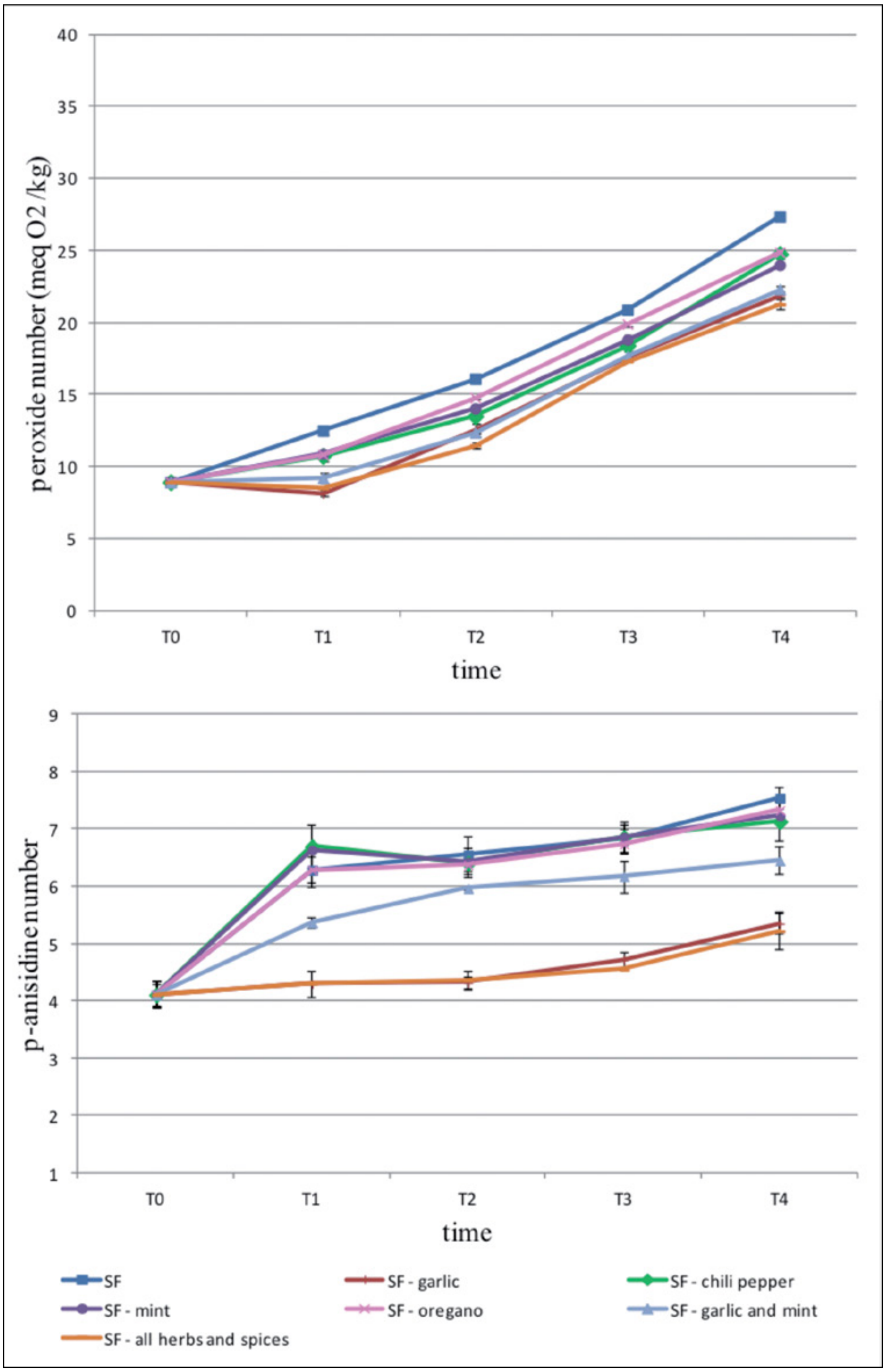

Fig. 4 - Peroxide number and p-anisidine value of sunflower oil, without herbs and spices and with different herbs and spices, as a function of storage.

ed mint and garlic, which was lower than that for other herbs and spices. For SBO, the worst *p*-anisidine values were found in SBO with added oregano (the oregano showed, in the case of SBO, an unusual pro-oxidant effect).

The sensorial test underlined differences among the covering oils for each vegetable at T0 and at T3 (fresh product and product at its sell-by date). Table 2 shows the results for quantitative descriptive analysis for AUSFO compared to AUEVO and with AUSBO at T0 and at T3. At T0, AUEVO was significantly different ($p < 0.05$) from AUSFO and AUSBO with respect to its color and bitterness, which were judged to be higher than

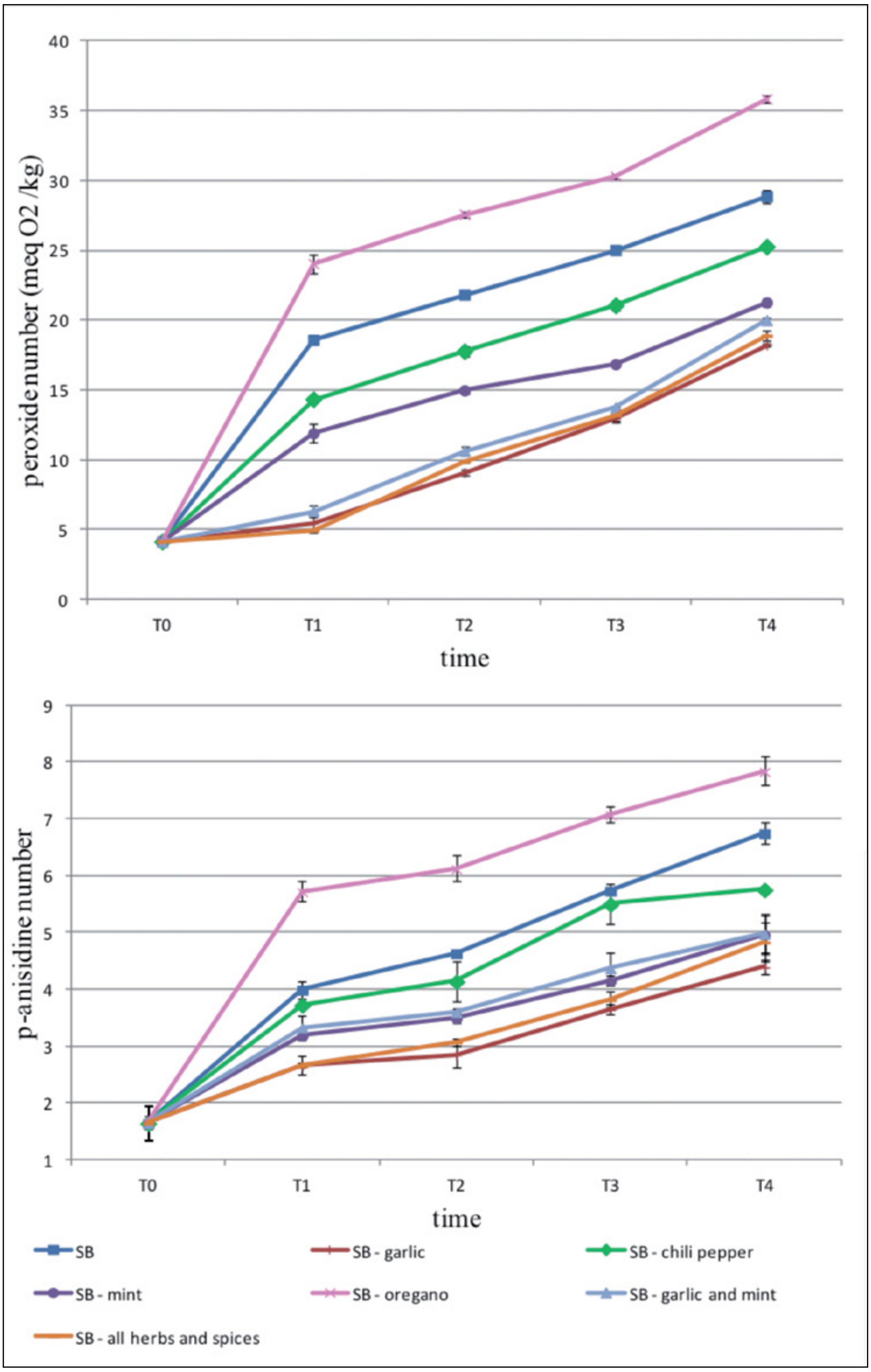

Fig. 5 - Peroxide number and *p*-anisidine value of soybean oil, without herbs and spices and with different herbs and spices, as a function of storage.

those found for the other oils. These differences could be explained by the characteristics of EVO. AUSBO was found to have lower rancidity when compared with the other samples. At the sell-by date, the quality of AUSBO differed from the other oils in its hardness, chewiness, and bitterness. AUSBO was judged slightly harder, less gummy, and less bitter than the other products. Table 3 shows the results for DTSFO as compared to DTEVO and DTSBO at T0 and at T3. At T0, DTEVO was judged to differ from DTSFO and DTSBO with respect to its bitterness, which was slightly higher than that of the other products. DTSBO was found to have lower

Table 2 - Sensory evaluation scores of AUSFO, AUEVO and AUSBO at T0 and T3.

Sample	Color[A]	Hardness[B]	Chewiness[C]	Rancidness[D]	Saltiness[D]	Bitterness[D]
AUSFO T0	6.70[a]	6.93[a]	5.96[a]	1.33[a]	4.46[a]	2.67[a]
AUEVO T0	7.27[b]	7.10[a]	5.6[a]	1.13[b]	4.16[a]	3.13[b]
AUSBO T0	6.63[a]	7.03[a]	5.30[a]	0.91[c]	4.13[a]	2.47[a]
AUSFO T3	6.30[a]	5.39[a]	6.65[a]	1.22[a]	4.78[a]	3.96[a]
AUEVO T3	6.57[a]	5.48[a]	6.21[b]	1.30[a]	4.48[a]	3.60[a]
AUSBO T3	6.29[a]	6.43[a]	5.43[a]	1.45[a]	4.71[a]	2.58[b]

n = 18; T0 = 0 months; T3 = 18 months.
Pairs (AUSFO T0 compared with AUEVO T0 and with AUSBO T0; AUSFO T3 compared with AUEVO T3 and with AUSBO T3) with the different letters within the same column are significantly different ($p < 0.05$).
AUSFO: aubergins in sunflower oil.
AUEVO: aubergins in extra-virgin olive oil.
AUSBO: aubergins in soybean oil.
[A] = Color: 0 = extremely light to 9 = extremely dark.
[B] = Hardness: 0 = extremely soft to 9 = extremely hard.
[C] = Chewiness: 0 = none to 9 = extremely gummy
[D] = Rancidness, saltiness, and bitterness: 0 = none to 9 = extremely strong

Table 3 - Sensory evaluation scores of DTSFO, DTEVO and DTSBO at T0 and T3.

Sample	Color[A]	Hardness[B]	Chewiness[C]	Rancidness[D]	Saltiness[D]	Bitterness[E]
DTSFO T0	6.88[a]	6.73[a]	4.73[a]	1.01[a]	5.98[a]	2.66[a]
DTEVO T0	6.67[a]	6.81[a]	4.83[a]	1.23[a]	6.32[a]	3.12[b]
DTSBO T0	6.65[a]	6.26[a]	4.69[a]	0.86[b]	7.39[b]	2.53[a]
DTSFO T3	6.81[a]	6.63[a]	4.93[a]	1.67[a]	5.57[a]	3.12[a]
DTEVO T3	7.43[b]	6.43[a]	5.13[a]	2.13[b]	6.37[b]	3.16[a]
DTSBO T3	7.06[a]	6.72[a]	4.13[b]	1.72[c]	5.45[a]	3.06[a]

n = 9; T0 = 0 months; T3 = 18 months.
Pairs (DTSFO T0 compared with DTEVO T0 and with DTSBO T0;   DTSFO T3 compared with DTEVO T3 and with DTSBO T3) with the different letters within the same column are significantly different ($p < 0.05$).
DTSFO: dried tomatoes in sunflower oil.
DTEVO: dried tomatoes in extra-virgin olive oil.
DTSBO: dried tomatoes in soybean oil.
[A] = Color: 0 = extremely light to 9 = extremely dark.
[B] = Hardness: 0 = extremely soft to 9 = extremely hard.
[C] = Chewiness: 0 = none to 9 = extremely gummy.
[D] = Rancidness, saltiness, and bitterness: 0 = none to 9 = extremely strong.

rancidity and saltiness than the other samples. At T3 the DTEVO was judged to differ from the other samples in its color and rancidness, and DTSBO was reported to be less gummy and less rancid than the other oil samples.

4. CONCLUSIONS

The results obtained from this study underline the higher resistance to oxidation of vegetables canned in SBO and in EVO. A higher concentration of secondary oxidation catabolites was observed in oils covering dried tomatoes than in oils covering aubergins. This might be related to the additive protective effects of antioxidant compounds found in the vegetables and the antioxidant effects of added aromatic herbs and spices (HUNG and DUY, 2012). Data obtained from the case study, conduct to investigate the efficacy as antioxidants of aromatic herbs and spice present as ingredients in the traditional recipes for considered canned vegetables, confirm the higher antioxidant power found upon addition of all herbs and spices considered in the recipe, of an added mixture of mint and garlic, or of added garlic alone, as compared to the pure oils or the oils with other aromatic herbs and spices added, and the minor effects on secondary oxidation of the oils with added mint and garlic. The sensorial investigation partially confirmed the analytical data at T0 with the finding of lower rancidity and, at the sell-by date, a better consistency and lower bitterness of aubergins in SBO. A lower rancidity at T0 and at T3 a better consistency and a lower rancidity were found for dried tomatoes in SBO. The lowest free acidity value, peroxides number, and *p*-anisidine value for aubergins and dried tomatoes in SBO, and the results of sensorial investigation underline the stability to oxidation and the validity of SBO as covering oil in canned vegetables production.

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