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Original article

# Green Onion (*Allium Cepa L.*) Leaves As Natural Additive For Improving Vegetable Oil Quality In Canned Tuna

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**Abstract**

Soybean oil is among the most popular vegetable oils, and is widely used in the food industry, in particular in canned tuna (CT). During processing, soybean oil oxidation induces changes that result in a lower quality. Thus, in this study, we aimed to enrich soybean oil (CT covering oil) using onion leaf powder (OLP) as source of natural antioxidants with potential health promoting effects. The OLP was dried under optimized conditions and added to soybean oil at four different doses (0%; 0.5%; 1%; 1.5% and 2%). All unenriched and enriched soybean oils were used as covering oil in CT which were sterilized at 115 °C and 1.3 bar for 75 min. Quality indices including color, total phenolic content (TPC), total flavonoid content (TFC), antioxidant activity (TEAC), fatty acid composition, and peroxide value (PV) of CT covering oil were carried out on different doses of added OLP as well as on the control sample. The obtained results showed that the addition of OLP in CT allowed the enhancement of the oil covering color that became close to that of extra virgin olive oil. In addition, our outcomes revealed that the addition of OLP improved soybean oil functional properties by significantly increasing of TPC, TFC and TEAC ($P<0.05$) of enriched soybean oil as compared to unenriched soybean oil. High values of TPC (0.65 mg GA/ g oil), TFC (2.07 mg GA/g oil) and TEAC (0.74 mg Trolox/ g oil) were recorded in oil enriched with 2% of OLP. Furthermore, the oils enriched with different doses of OLP had PV values in the range of Codex Standards. Remarkably, the addition of OLP in the CT covering oil led to an increase of polyunsaturated fatty acids contents, indicating the preventive effects of OLP against lipid oxidation of oil after heat treatment. The use of OLP, as a valuable by-product, seems to be an efficient nutraceutical food supplement for the improvement of nutritional quality and functional properties of CT.

**Keywords:** Covering oil, Canned tuna, Onion leaves, Natural antioxidants, Quality, Lipid oxidation.

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## INTRODUCTION

Tuna fish (*Skipjack tuna*) is known by its richness in protein, micro- and macroelements, unsaturated fatty acids and fat-soluble vitamins of high nutritional quality. However, it is highly perishable due to several bacterial and enzymatic reactions which affect its nutritional composition, odors and flavours (Pataca et al., 2021). Therefore, canning is considered as one of the most effective means for tuna fish preservation (Mohan et al., 2014). In addition, the canning process allows the distribution of food products on a global scale, taking advantage of a broad time frame for distribution, storage and consumption under strict food safety conditions (Aubourg, 2023). For instance, canned tuna (CT) is one of the most widely consumed canned seafood products due to its nutritional value, long shelf life, and the reasonable relationship between its nutritional quality and price (Kalogiouri et al., 2021). The demand for value-added canned products packed in different filling media, such as, oil, curry and sauce, has increased worldwide (Gomez-Limia et al., 2021). Vegetable oils, such as soybean oil are widely used as filling media in the tuna canning industry (Medina et al., 1998; Naseri et al., 2012). Soybean oil has a high content of polyunsaturated fatty acids (PUFA) susceptible to oxidation reactions contributing to its reduced oxidative stability during storage and heat treatments such as sterilization and leading to the formation of harmful compounds, off-flavors, and a loss of nutritional value. Oxidation is essentially a chemical reaction that occurs when oils are exposed to heat, light, or air, resulting in rancidity, which not only affects taste but can also have health implications for consumers (Tinello et al., 2020). In order to prevent oxidation in CT products, the filling medium is usually enriched with antioxidants. Indeed, added antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tertiary butylhydroquinone (TBHQ), and propyl gallate allow to protect the product unsaturated fatty acids from oxidation by neutralizing free radicals and inhibiting hydroperoxides and thus maintaining the sensory and nutritional qualities (Ferreiro et al., 2022).

Currently, the food industry opted to replace the synthetic antioxidants with natural antioxidants which are considered safer and healthier and meet the increased attention of consumers to health (Taghvaei & Jafari, 2015; Kalogiouri et al., 2021). Agro-food products, by-products and wastes are considered as important source of phenolic compounds which contribute to the development of new functional food (Tinello et al., 2020). In the case of vegetable oil enrichment, several agents (plant extracts, pure compounds, essential oils, and plant parts) are added in different forms (fresh, dried, encapsulated, in solution) using different technologies such as dilution, maceration, blending, and co-processing.

Among the agricultural by-products, green onion leaves are rich, as bulbs, in several vitamins, folate, fibers, sulfur compounds, and bioactive flavonoids with high antioxidant activity. Despite this richness, onion leaves are generally discarded and not consumed. Accordingly, their valorisation as natural additive in perishable food products particularly those canned in refined vegetable oil seems to

be a promising approach for reducing oxidation and extending shelf life. For instance, the enrichment of CT with onion leaves in stable and disponible form such as powder could enhance nutritional and sensorial quality, as natural preservative, antioxidant and colorant agent of both CT and covering oil.

In this context, the objective of the present work is to study the effect of the addition of green onion leaf powder (OLP) to CT on the covering vegetative oil bioactive composition and quality after sterilization.

## MATERIALS and METHODS

### Sample Preparation

#### *Preparation Of Green Onion Leaf Powder*

The used green onions (*Allium cepa*) were harvested from the same field and farmer in Amdoun (Beja, Tunisia) from February to March 2022. Green onion leaves were cut into 1 mm thickness, 7 cm length, and 1 cm width. Green onion samples were dried in a convective air dryer (Figure 1) at air temperature of 45 °C and air velocity of 0.6 m $s^{-1}$ using an innovative drying process : interval starting accessibility drying (ISAD) which is based on an alternative active periods ($t_{ON}$ = 5 s) to eliminate water available on the surface and tempering periods ($t_{OFF}$ = 3 min) to allow water to diffuse through the product (Hajji et al, 2020; Gliguem et al, 2021). Drying treatment ended when samples water activity reached 0.45 with a water content of 12 g/100 g db.

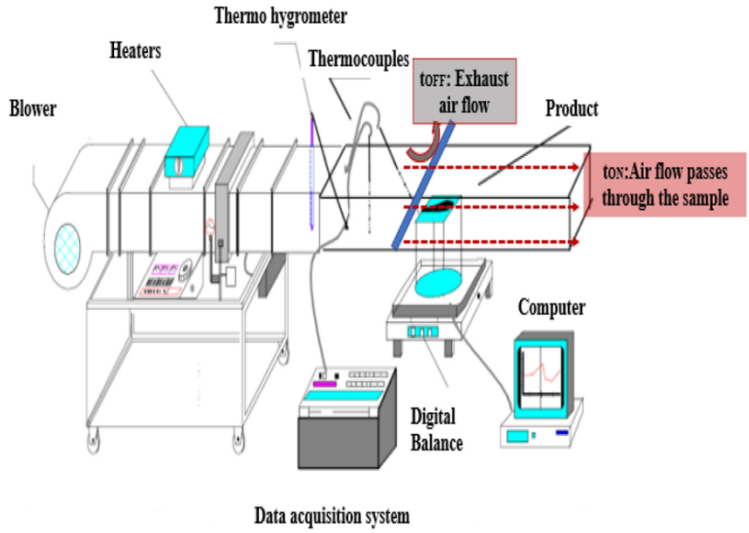


**Figure 1.** Drying apparatus.

Dried leaves were then ground in order to obtain a powder. OLP obtained presents water and oil holding capacities of 11.45 and 3.77 g $g^{-1}$, respectively. OLP contained total polyphenols and flavonoid contents of 0.93 g gallic acid/100 g db and 2.85 g quercetin/100 g db, respectively, and had an antioxidant activity of 0.38 g Trolox/100g db.

### *Preparation Of Canned Tuna Samples*

CT samples were prepared from raw tuna fish (*Skipjack tuna*) according to the protocol (Figure 2) used by "SOPEMSUD" manufacturing unit (Ben Guerdan, Tunisia).

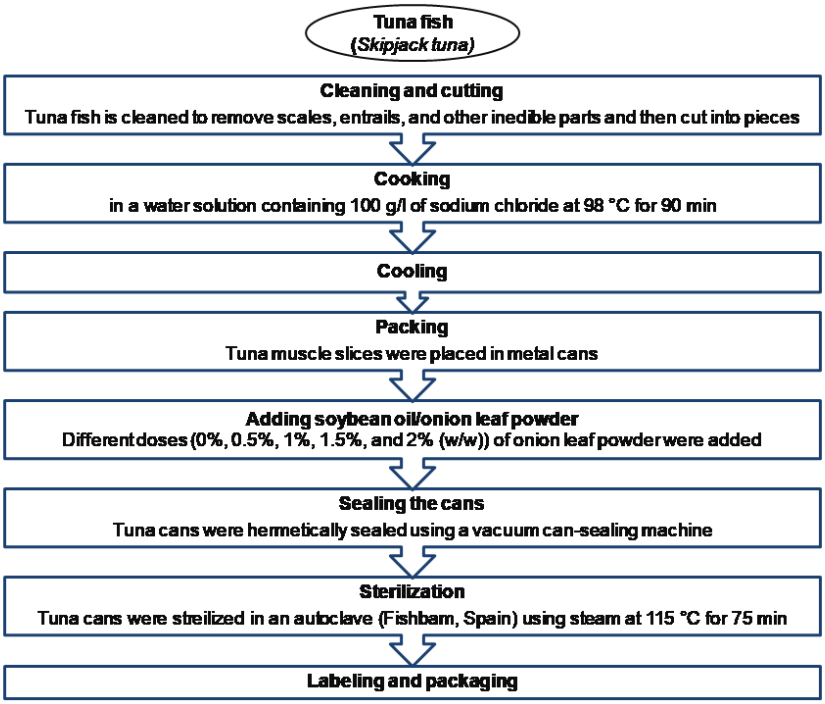


**Figure 2.** Canned tuna preparation protocol.

After removing the head and entrails, the samples were thoroughly washed. Tuna fish were then cut into pieces and cooked, in a water solution containing 100 g/l of sodium chloride, at 98 °C for 90 min. After cooling, whole slices of tuna muscle were placed in metal cans. Different levels (0%, 0.5%, 1%, 1.5%, and 2% (w/w)) of OLP were added to CT (30% soybean oil + 70% tuna). The prepared cans were then hermetically sealed using a vacuum can-sealing machine. Sterilization of the canned fish was conducted in an autoclave (Fishbam, Spain) using steam at a temperature of 115 °C for 75 min; the process allowed to achieve industrial sterility of the products. The canned products were cooled down using water with a counter pressure of 1.3 Bar.

### Color Measurement

The color of CT covering oil samples was measured using a chromameter (Konica Minolta CR-410, Tokyo, Japan). Three parameters were measured $L^*$ indicates (brightness/darkness), $a^*$ (redness/greenness) and $b^*$ (yellowness/blueness).

**Assessments Of Antioxidant Properties**

***Extract Preparation***

The ethanolic extract of CT covering oil samples was prepared according to the method described in a previous study (Abcha et al., 2018). In brief, 2 g of covering oil and 5 g of absolute ethanol were mixed for 5 min. Then, 5 g of hexane were added. After that, the mixture was centrifuged at 5000 rpm for 20 min at room temperature. After centrifugation, the hexane layer was removed. The final mixture was filtered through a hydrophobic membrane (0.45 µm). The extract was stored at 4 °C until analysis (Abcha et al, 2018).

***Total Phenolic Content Determination***

The total phenolic content (TPC) was determined according to the method described in a previous research work (Ben Haj Said et al., 2013). A volume of 0.125 ml of the extract, 0.5 ml of distilled water, and 0.125 ml of the Folin–Ciocalteu reagent were mixed for 6 min. Then, 1.25 ml of $Na_2CO_3$ (7%) and 1 ml of distilled water were added. Finally, the mixture was incubated in the dark for 90 min. The absorbance was determined at a wavelength of 760 nm. The standard was prepared in the same conditions with gallic acid.

***Total Flavonoid Content Determination***

For the determination of total flavonoid content (TFC), 0.25 ml of the extract and 0.075 ml of $NaNO_2$ (7%) were shacked for 6 min. Then, 0.15 ml de freshly prepared $AlCl_3$ solution ($6H_2O$, 10%) were added and the mixture was sacked for 5 min. Finally, 0.5 ml of NaOH (1M) and 1.525 ml of distilled water were added. The absorbance was determined at a wavelength of 510 nm. The standard was prepared in the same conditions with quercetin.

***Antioxidant Activity Determination***

Different concentrations of the extract (10 to 100 µg/ml) were prepared. Then, 25 µl of the extract were added to 1 ml of DPPH ($4\times10^{-5}$ M) and the mixture was incubated in the dark for 60 min. The negative control was prepared by adding 25 µl ethanol to 1 ml DPPH. Finally, the absorbance was determined at a wavelength of 517 nm. Then, DPPH·scavenging activity (TEAC) was calculated using the following equation (Eq. 1) and expressed as g Trolox/100 g MS.

$$\text{TEAC} = \frac{\text{IC}_{50}\ (\text{trolox})}{\text{IC}_{50}\ (\text{sample})} \times 100 \qquad \text{(Eq. 1)}$$

With:

$IC_{50}$ (trolox): the concentration of the trolox that causes 50% loss of the DPPH activity;

$IC_{50}$ (sample): the concentration of the sample extract that causes 50% loss of the DPPH activity.

**Lipid Oxidation Assessements**

***Fatty Acid Composition***

The fatty acid composition of CT covering oil samples was determined according to the method described by the International Olive Council (COI, 2018). For each sample, 2 ml of heptane was added to 0.1 g of the sample, and then the mixture was stirred. Then, 0.2 ml of a methanolic solution of hydroxide of potassium (2M) were added. The tubes containing the mixture were closed with caps. Then, they were shaken vigorously for 30 s. The mixture was allowed to stand until a clear top layer appeared. Finally, the top layer was removed and the rest was injected into the gas chromatograph.

The initial chromatograph temperature was set at 165°C for 10 min. Then, gradually increased to 200°C at a rate of 1.5°C/min. The injection temperature was maintained between 220 and 250°C. 1 µl of sample was injected. The main constituents have been identified by comparing their retention indices with those reported in the literature.

***Peroxide Value Determination***

The peroxide value (PV) of different CT covering oil samples was determined according to the the International Olive Council (COI, 2018). A chloroform solution (10 ml) was added to 2 g of oil. The mixture was then agitated. Then, 15 ml of acetic acid and 1 ml of potassium iodide solution were added. The mixture was incubated in the dark for 5 minutes at room temperature. Finally, 75 ml of distilled water and 1 ml of starch paste as a color indicator were added. The solution was titrated with sodium thiosulfate until the pink-violet color completely disappeared. A blank was performed under the same conditions without oil. The PV, expressed in milli-equivalents of active oxygen per kilogram oil (mEq $O_2$/kg), was calculated using the following equation (Eq. 2).

$$\text{PV (mEq O}_2\text{/kg)} = \frac{(v_0 - v_s) \times T \times 1000}{m} \qquad \text{(Eq. 2)}$$

With:

$V_0$: volume of thiosulfate added for blank (ml);

$V_s$: volume of thiosulfate added for the sample (ml);

T: concentration of sodium thiosulfate solution (mol/l);

m: sample weight (g).

**Statistical Analysis**

The results obtained for the different properties of CT covering oil samples were submitted to statistical analyses, by comparing the mean values in ANOVA with *post hoc* test of Tukey. The results were expressed as mean values ± standard deviation. For this, a level of significance of 5% was considered ($p$<0.05), and SPSS (version 17.0) statistical software was used.

## RESULTS and DISCUSSION

### Effects Of Onion Leaves On Canned Tuna Covering Oil Color

Results of color measurements on CT covering oil samples enriched with different doses of green OLP, after heat treatment, are shown in Figure 3 and Table 1.

**Table 1.** Color parameters of canned tuna covering oil enriched with different doses of onion leaf powder.

| OLP dose (%) | Color parameters (-) | | |
|---|---|---|---|
| | $L^*$ | $a^*$ | $b^*$ |
| **0** | $77.493^{a}$±0.745 | $-02.691^{a}$±0.124 | $10.793^{a}$±0.633 |
| **0.5** | $76.283^{b}$±0.768 | $-06.127^{b}$±0.699 | $18.430^{a}$±0.564 |
| **1** | $71.380^{c}$±0.479 | $-10.147^{c}$±0.120 | $27.351^{b}$±0.226 |
| **1.5** | $70.153^{d}$±0.423 | $-10.450^{c}$±0.138 | $28.623^{c}$±0.221 |
| **2** | $68.078^{e}$±0.511 | $-11.460^{d}$±0.205 | $29.530^{d}$±0.265 |

Data are recorded as the mean±standard deviation. For each column, values followed by different letters are statistically different at $P < 0.05$.

As shown in Figure 3 and Table 1, soybean oil used as a liquid medium in CT presented a pale yellow color with low values of greenness ($a^*$) and yellowness ($b^*$) parameters. In fact, refined vegetable oils lost their natural pigments after degumming, deacidification, bleaching, deodorization, and dewaxing during refining process (Chen & Sun, 2023).

Addition of OLP with different doses changed all color parameters. Indeed, the addition of OLP allowed a decrease in the luminosity ($L^*$), an increase in the greenness ($a^*$) and yellowness ($b^*$). Hence, oil covering color of OLP enriched CT with became close to that of olive oil which is widely appreciated by consumers.

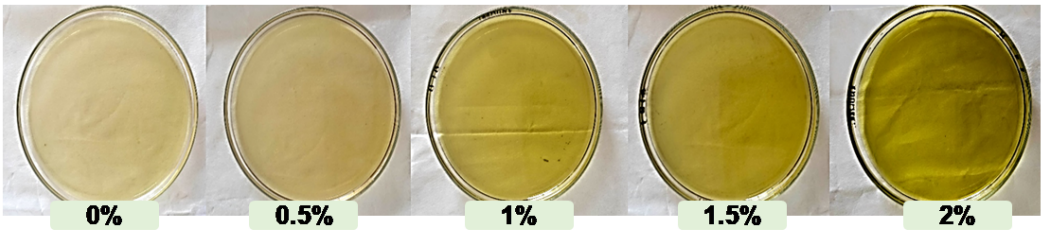


**Figure 3.** Color of canned tuna covering oil enriched with different doses of onion leaves.

These results could be attributed to the increase in chlorophylls and carotenoids concentration following the addition of green OLP (Suri et al, 2019). In fact, oil green color is generally attributed to the presence of chlorophylls, while yellow color is attributed to carotenoids concentration (Ramos-Escudero et al., 2019; Suri et al., 2019).

These results seem to be very interesting because the addition of OLP allowed the enrichment of the CT covering oil in these natural pigments. In fact, carotenoids have several health promoting roles. More specifically, some carotenoids such as β-carotene are the precursors of vitamin A, which is

essential for humans. However, despite their nutritional value, carotenoids and even chlorophylls should be removed during vegetable refining process to avoid their negative effects on the appearance of vegetable oils (Chen & Sun, 2023).

### Effect Of Onion Leaves On Canned Tuna Covering Oil Antioxidant Properties

#### *Total Phenolic And Flavonoid Contents*

Results of TPC and TFC of CT covering oil samples unenriched and enriched with different doses of green OLP are presented in Figures 4 and 5.

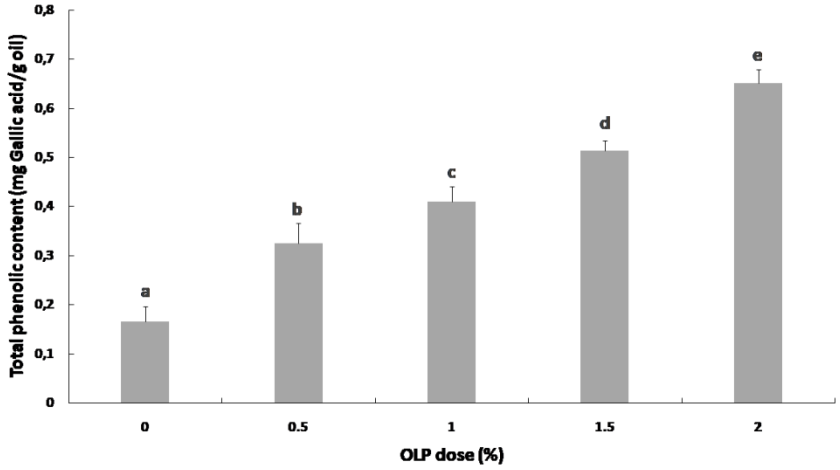


**Figure 4.** Total phenolic content of canned tuna covering oil enriched with different doses of onion leaves.

Data are recorded as the mean±standard deviation. Values followed by different letters are statistically different at $P < 0.05$

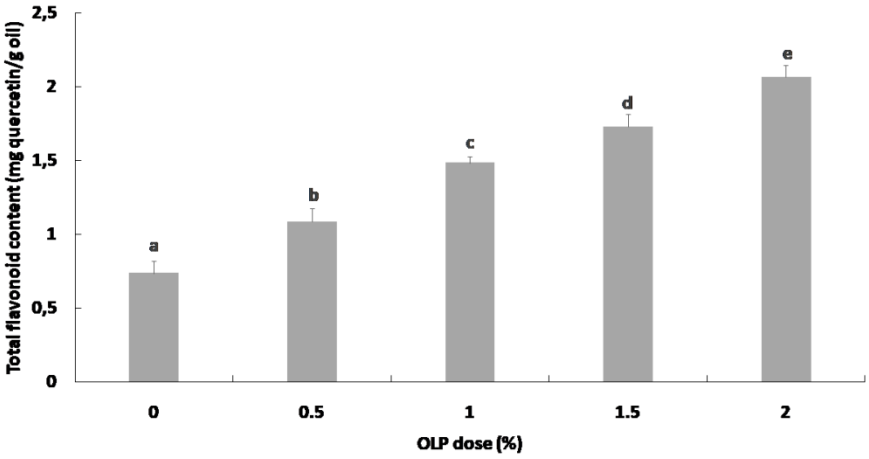


**Figure 5.** Total flavonoid content of canned tuna covering oil enriched with different doses of onion leaves.

Data are recorded as the mean±standard deviation. Values followed by different letters are statistically different at $P<0.05$

The obtained results showed that soybean oil used as liquid medium in CT is very poor in total bioactive polyphenols (Figure 4) and flavonoids (Figure 5). Indeed, refined vegetables oils deliberately

lost their natural bioactive compounds during the refining process to ameliorate their purification and appearance during storage (Mavlanov et al., 2024).

However, the total phenolic and flavonoid contents of the covering oil increased linearly ($R^2$ = 0.9) with increasing the dose of added OLP (Figures 4 and 5). Indeed, TPC and TFC increased 294% and 180% for the dose 2%, respectively, as compared to the covering oil of unenriched-CT. This significant gain in phenolic compounds is essentially correlated with the richness of onion (*Allium cepa*) in these bioactive compounds. Several previous studies (Kurnia et al, 2021; Ben Haj Said et al., 2025a) reported that onion leaves are rich in phenolic compounds with contents very close to those of the bulbs, the most consumed part. Among the identified phenolic acids cinnamic acid, ferulic acid, p-coumaric acid and sinapic acid are the most abundant. In addition, onions are especially rich in flavonoids and particularly in quercetin with high interesting bioactivities.

Results obtained in this work concerning the enrichment of CT with OLP are similar to those described by Tarchoune et al. (2019). These authors demonstrated that the enrichment of olive oil with olive leaves led to the enhancement of the flavonoid content by 22% for the Neb Jmal variety and 160% for the Ouesleti variety. They explained this difference by the richness of plant leaves in flavonoids.

The obtained results agree with those of previous studies (Saoudi et al., 2016) that reported that after 6 hours of heating at 180 °C, the decrease in the phenol content in unflavoured soybean oil was higher than that of flavoured oil with rosemary and thyme. Another previous study (Karoui et al., 2011) showed that refined corn oil flavoured with thyme loses 30% of all its phenolic compounds after heating at 180°C for 30 min while unflavoured refined corn oil loses all of its phenolic compounds after heating at 150°C for 30 min.

Moreover, during CT storage, the degradation of phenolic compounds in the covering oil flavoured with chilli and pepper was slower (Gomez-Limia et al., 2021).

On the other hand, several previous studies have proven the impact of covering medium enrichment with phenolics coupounds on canned fish products. For instance, the polyphenols extracted from the extra virgin olive oil were tested for their ability to inhibit lipid oxidation in canned tuna (*Tuna alalunga*). An antioxidant effect was observed in treated tuna by employing 400 ppm of the extra virgin olive oil polyphenols in the packing medium, thus showing a similar effect as compared to 100 ppm of a 1:1 mixture of the synthetic antioxidants BHT and BHA (Medina et al., 1998). Similarly, the use of natural phenolic compounds was found to inhibit lipid oxidation in CT during long-term storage and to be effective in lowering the lipid oxidation induced TBARS (Yuan et al., 2019).

***Antioxidant Activity***

Results of antioxidant activity of covering oil used as liquid medium in CT are presented in Table 2.

**Table 2.** Antioxidant activity of canned tuna covering oil flavoured with different doses of onion leaves.

| OLP dose (%) | TEAC (mg Trolox/g oil) |
|---|---|
| **0** | $0.064^{a}$±0.013 |
| **0.5** | $0.314^{b}$±0.122 |
| **1** | $0.509^{b}$±0.057 |
| **1.5** | $0.622^{c}$±0.096 |
| **2** | $0.739^{c}$±0.063 |

Data are recorded as the mean±standard deviation. Values followed by different letters are statistically different at $P < 0.05$.

Table 2 shows that the soybean oil used as oil-packing medium in CT has low antioxidant activity, i.e. 0,064 mg Trolox/g oil, which was expected given described data in the literature. Indeed, a previous study (Tinello et al., 2020) reported that soybean oil possesses a low antioxidant activity since it doesn't contain polyphenols. However, the antioxidant activity of covering oil increased linearly with the increase of added OLP dose ($R^2 = 0.900$). For instance, a 10-fold increase in oil antioxidant activity is noted when adding 2% of OLP in CT. Indeed, several researchers have been interested in studying phenolic compounds of *Allium* species and classified them as natural antioxidants (Lu et al., 2011). Indeed, the onion (*Allium cepa*) leaves used in the present study are well characterised by their antioxidant activity due to their richness in phenolic and flavonoid compounds (Ben Haj Said et al., 2025a). Among phenolics identified by HPLC method in several previously studies, myricetin, quercetin, luteolin, kaempferol and rutin were the most predominant phenolic compounds (Elhadidy et al., 2014). Phenolic antioxidants present in onion leaves have good free radical scavenging and chelating properties (Banerjee, 2015). The incorporation of these compounds in covering oil helps to improve their thermal stability and preserves the nutritional properties of canned products.

This characteristic has led to the extensive use of *Allium* plants as antioxidant additives in a wide category of food products such as canned tuna (Ben Haj Said et al., 2025b), cheese (Gliguem et al., 2021), sausages, and meat (Yang et al., 2012). An increase in soybean oil antioxidant activity from 0 to 3.3 and 7.89 mg trolox/g oil was also noticed after the addition of 10% of ginger and saffron powder (Tinello et al., 2020). In fact, the authors explained this increase by a strong positive correlation between the antioxidant activity and the content of phenolic compounds.

Another previous study (Loizzo et al., 2021) reported an enhancement in antioxidant activity of the extra virgin olive oil enriched with two types of pepper (*Capsicum annuum* and *Aji limo*), with the highest value was observed for oil enriched with the *Aji limo* measured by both DPPH and ABTS tests. Higher antioxidant activity has a significant impact on retarding lipid oxidation in the food product. Indeed, the antioxidant effect of the packing oil is correlated to its richness in polyphenols which includes a wide range of constituents that could prevent the lipid degradation of CT during the different technological processing steps. The natural polyphenols can act as free radical acceptors as well as metal chelators. For instance, the use of a mixture of rosemary extract and curry leaf extract known for their

high polyphenol content was effective in inhibiting oxidation and increased salami shelf life of 33.3% (Demarco et al., 2022).

**Effects Of Onion Leaves On Lipid Oxidation Of Canned Tuna Covering Oil**

***Fatty Acid Composition***

The fatty acid composition of CT covering oil samples enriched with different doses of green OLP is shown in Table 3.

**Table 3.** Fatty acid composition of canned tuna covering oil enriched with different doses of onion leaves.

| **Fatty acid** | | **Fatty acid content (%w/w)** | | | | |
|---|---|---|---|---|---|---|
| | | **OLP dose (%)** | | | | |
| **Types** | **Name** | **0%** | **0.5%** | **1%** | **1.5%** | **2%** |
| Saturated fatty acids (SFA) | Myristic acid (*C14*:0) | 0.08 | 0.03 | 0.04 | 0.06 | 0.08 |
| | Palmitic acid (C16:0) | 10.21 | 8.55 | 9.61 | 10.25 | 10.86 |
| | Margaric acid (C17:0) | 0.08 | 0.06 | 0.13 | 0.08 | 0.11 |
| | Stearic acid (C18:0) | 3.81 | 3.83 | 3.79 | 3.73 | 3.57 |
| | Arachidic acid (C20:0) | 0.17 | 0.27 | 0.19 | 0.15 | 0.10 |
| Mono-unsaturated fatty acids (MUFA) | Palmitoleic acid (C16:1) | 0.11 | 0.07 | 0.06 | 0.07 | 0.09 |
| | Margaroleic acid (C17:1) | 0.05 | 0.03 | 0.03 | 0.05 | 0.08 |
| | Oleic acid (C18:1) | 26.86 | 26.46 | 26.19 | 25.95 | 25.50 |
| | Eicosenoic acid (C20:1) | 0.17 | 0.19 | 0.14 | 0.14 | 0.13 |
| Poly-unsaturated fatty acids (PUFA) | Linoleic acid (C18:2) | 52.65 | 54.15 | 53.73 | 53.36 | 53.38 |
| | Linolenic acid (C18:3) | 5.76 | 6.33 | 6.04 | 6.12 | 6.05 |

Generally, vegetable oils are rich in unsaturated fatty acids, such as monounsaturated and polyunsaturated fatty acids. These fatty acids make oils susceptible to oxidation (Kozlowska & Gruczyńska, 2019). The fatty acid composition of refined soybean oil heated at 115 °C for 75 min as function of different doses of added OLP, expressed as saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA), is summarized in Table 3.

The results showed that the most abundant SFA in all oil samples are palmitic acid (C16:0) and stearic acid (C18:0). The covering oil enriched with 2% of OLP contained higher levels of these fatty acids (10.86% of palmitic acid and 3.57% of stearic acid) as compared to others oils. Among MUFA, oleic acid (C18:1) was the main representative and its content ranged from 25.50% in covering oil enriched with 2 % of OLP to 26.86% in control. However, linoleic (C18:2) and linolenic (C18:3) acids were the dominant fatty acids among PUFA in all samples with high values observed in covering oil enriched with 0.5% of OLP (54.15 % of linoleic acid and 6.33% of linolenic acid). The covering oil without OLP contained lower levels of PUFA. Therefore, some preservative effects on PUFA compounds could be inferred from the presence of OLP in the covering medium. This observation

revealed also that the addition of OLP may enhance oxidative stability of CT covering oil during long-term storage. A PUFA retention was also detected in canned salmon (*Salmo salar*) when including seaweed (*Ulva lactuca*, *Durvillaea antartica*, and *Pyropia columbina*) extracts with high contents of polyphenols in the covering liquid (Ortiz et al., 2014).

***Peroxide Value***

Oxidation degree on covering oil of CT as a function of different doses of added OLP was determined by measuring their peroxide value (PV) (Figure 6).

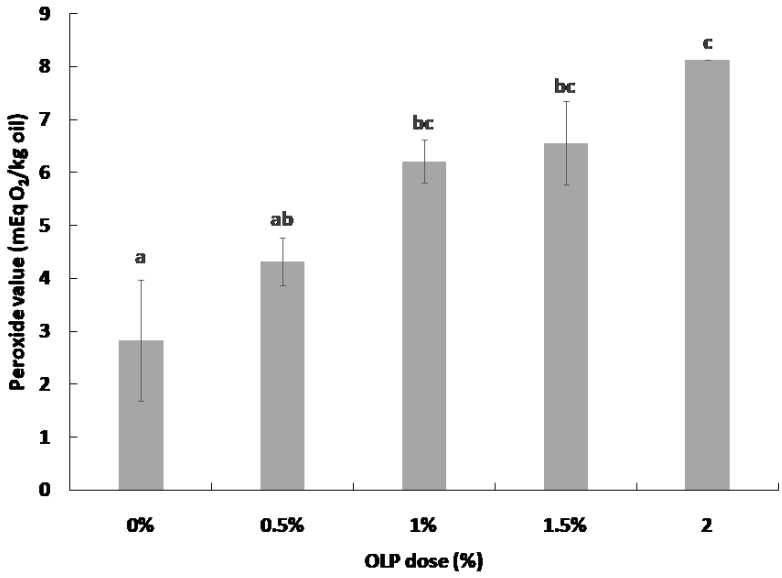


**Figure 6.** Peroxide values of canned tuna covering oil enriched with different doses of onion leaves.

Data are recorded as the mean±standard deviation. Values followed by different letters are statistically different at $P < 0.05$.

PV is the most common parameter used to measure total peroxides which are the primary oxidation products formed in oils during the oxidation process and reflects the oil quality (Romano et al, 2021). In this study, the PV values of the CT covering oils depended on the doses of OLP, as shown in Figure 4. In the absence of OLP, PV of oily media (refined soybean oil heated at 115 °C for 75 min) was 2.83 meq $O_2$/kg. This result is in agreement with Medina et al (1998) who noted that PV of refined soybean oil extracted from CT was 2.18 meq $O_2$/kg. In the presence of OLP, the PV values obtained in this work, ranged from 4.31 meq $O_2$/kg to 8.13 meq $O_2$/kg for oily media enriched with 0.5% and 2% of OLP, respectively. These values are similar to those of virgin olive oil (4.50 meq $O_2$/kg) and extra virgin olive oil (9.50 meq $O_2$/kg) extracted from CT (Medina et al., 1998).

These results may be explained by the presence of chlorophylls in OLP that are responsible for green color in olive oil and onion leaves. Indeed, similar chlorophyll contents were observed in onion leaves and in olive oils (Ayadi et al., 2009). Therefore, the relative increase in PV values of refined soybean oil in CT with increase of OLP doses may be due to the chlorophyll contents, which act as

sensitizers promoting the formation of singlet oxygen under oil processing (Choe & David, 2006). A previous study (Phuong et al, 2020) reported that the PV of soybean oil enriched with rambutan peel powder (4.56±0.02 meq $O_2$/kg) was higher than PV of control (3.14±1.03 meq $O_2$/kg) at the first day of storage.

In this study, the PV values of CT covering oil increased with the increase of the added doses of OLP. However, in spite of the increase of PV values in the enriched covering oils samples, they all kept a low oxidation state after thermal processing indicating their good quality. Indeed, in accordance with *Codex Alimentarius*, a PV limit of fats and oils is given, up to 10 meq $O_2$/kg (Abdo et al., 2023).

## CONCLUSION

Interesting results were obtained in relation to the enrichment of refined vegetable oil used as liquid covering medium in CT. Indeed, the content of total phenols and flavonoids as well as the antioxidant activity increased with OLP dose increasing.

The use of green OLP as a natural additive in vegetable oils used as liquid medium of CT offers a promising strategy to improve the oil and product quality and a good alternative to replace synthetic antioxidants. Indeed, the addition of green onion leaves in powder form in CT allowed the enhancement of the oil covering color that became close to that of extra virgin olive oil, the enrichment of its bioactive composition in polyphenols and flavonoids, and the enhancement of its antioxidant activity. It led also to an increase of polyunsaturated fatty acids contents, indicating the preventive effects of onion leaves against lipid oxidation of soybean oil after heat treatment.

Further researches are needed to assess the impacts of the addition of OLP on CT quality and on the vegetable covering oil during long-term storage under different conditions.

### Additional Declaration

#### *Author Contributions*

In this study, the contribution of the authors was equal; both authors contributed equally to the development of the research idea, data analysis, writing and proofreading stages.

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#### *Responsible Artificial Intelligence Statement*

No artificial intelligence support was received in any part of this study.

#### *Conflicts of Interest*

The authors declare that there are no conflicts of interest related to the publication of this study.

***Ethics Approval***

In all processes of this study, the principles of Pen Academic Publishing Research Ethics Policy were followed.

This study does not require ethics committee approval as it does not involve any direct application on human or animal subjects.

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