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## Effects of adding tomato peel powder on lipid oxidation of lamb meat during refrigerated storage

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**Abstract** The results revealed that the pH value of fresh meat patties (day 0) decreased ( $p < 0.05$ ) with increasing tomato peel powder concentration in the samples ( $5.77 \pm 0.08$  and  $5.55 \pm 0.05$  for the C and T3 samples respectively) and it increased ( $p < 0.05$ ) during the storage. The refrigerated storage increased significantly ( $p < 0.05$ ) the TBA value of all the samples ( $0.23 \pm 0.05$  -  $0.44 \pm 0.02$  mg MDA/kg in the C samples). However, adding 3% of tomato peel powder reduced lipid oxidation and showed the lowest TBA value ( $0.29 \pm 0.02$  mg MDA/kg). These results indicate that tomato peel powder can be exploited as a food supplement to reduce lipid oxidation and improve meat quality.

**Keywords:** Lipid oxidation, Meat, pH, Tomato peel

### Introduction

In recent years, the increase in consumption of fast foods has led to a significant increase in the production of ground meat products; grinding meat modifies the muscle structure and facilitates lipid oxidation (Devatkalet *et al.*, 2010). In addition, this phenomenon is the principale origin of quality degradation of meat and meat products, because of their high fat quantity and low water activity; it reduces nutritional and sensory quality of meats and rises toxic compounds that can promote several pathologies (Domínguez *et al.*, 2019).

However, during the refrigerated storage, meats products are subject to several undesirable changes, because of microbial multiplication and lipid oxidation that cause quality reduction, meat spoilage, and economic loss (Sallam and Samejima, 2004), this quality deterioration may have great impact on consumer's health. Thus, reducing lipid oxidation in meat products by using artificial additives with antioxidant function to prevent undesirable changes in

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their qualities seems to be a good solution for improving meat quality and increasing consumer safety (Aminzare *et al.*, 2019).

Nowadays, the use of synthetic antioxidants has been limited because of their high toxicity (Ribeiro *et al.*, 2019). The incorporation of natural antioxidant in meat products seems to be a good method to prevent the lipid oxidation reactions; these substances react with free radicals and quench the metal ions. (Hussein *et al.*, 2019).

Tomato (*Solanum lycopersicum*) is one of the most widely grown vegetables in the world that is consumed fresh or as processed product. It is a rich source of vitamins, minerals, and fiber, and a dietary source of other healthy phytonutrients and antioxidants such as carotenoids and flavonoids (Pernice *et al.*, 2010). These constituents are important for their anticarcinogenic, cardioprotective, antimicrobial, anti-inflammatory, and antioxidant properties (Viuda-Martos *et al.*, 2014).

The content of these active compounds depends on several factors like the tomato variety, the environmental conditions, and the transformation conditions (Vadez-Morales *et al.*, 2014). The tomato industry produces a large quantity of by-products which are mainly composed of peels, seeds and pulps residues that account for 7.0–7.5% of raw materials (Nour *et al.*, 2018). These wastes remain unutilized and aggravate environmental pollution (Salem, 2013).

Many studies have found that the consumption of tomatoes decreases the risk of cardiovascular diseases and digestive system cancers (Osterlie and Lerfall, 2005). This positive effect is the result of the lycopene content which is found in the peel fraction with a five times higher concentration than the pulp (on wet basis); this compound can decrease the risk of chronic diseases by protecting cells against oxidative damage (Kim *et al.*, 2011). Therefore, it ensures the antioxidant activity of tomatoes (Ammar and Aboalfa, 2017).

Therefore, the aim was to determine the antioxidant potential of tomato peel powder and investigate the effects of its incorporation on lipid oxidation of lamb meat patties refrigerated for 12 days.

## **Materials and methods**

### ***Preparation of the raw materials of the experiment***

A quantity of lamb meat was obtained from a local market in the region of Mostaganem located in the North West of Algeria. The meat samples were immediately transferred to the Biotechnology Applied to Agriculture and Environmental Preservation Laboratory of Higher School of Agronomy where it was chopped in order to facilitate the sampling for our experimentation.

The fruits of tomato studied were obtained from the local market of Mostaganem, the fruits were harvested at full maturity, cleaned with tap water and rinsed in warm distilled water for a few seconds in order to soften the skin and facilitate detachment of the peel. After the recovery of all the quantity of peel necessary for the realization of our experiment, it was placed in an oven drier regulated at  $37^{\circ}\text{C} \pm 1^{\circ}\text{C}$  for 48h until complete dehydration. The peel was ground to a fine powder to pass through sieve and it was packed in polyethylene bags and left at  $-18^{\circ}\text{C}$  until further use.

### ***Sample preparation***

Lamb meat was divided to four batches. The first batch was left without any addition (Control) while the other batches were treated with three proportions of tomato peel powder (TPP) as follows: C (0% of TPP), T1 (1% of TPP), T2 (2% of TPP), T3 (3% of TPP). After mixing the mixture was shaped manually to obtain patties of 8 cm diameter and 0.4 mm thickness. Treatments and control samples were refrigerated ( $+4^{\circ}\text{C}$ ) for a storage period (day 0, day 6, day 12). During this time, we carried out the measurement of lipid oxidation and pH of meat.

### ***Total phenols and flavonoids content of TPP***

Total phenol content was measured by the Folin-Ciocalteu assay (Miliauskas *et al.*, 2004, as cited in the study of Khaouchene *et al.* (2016)). Briefly, 1 ml of methanolic extract was blended thoroughly with 5 ml of Folin-Ciocalteu reagent (2mol/L) for a few minutes. The mixture was allowed to stand for 5 min, followed by the addition of 4 ml of aqueous  $\text{Na}_2\text{CO}_3$  solution (75 g/L). The sample was remixed for 60 min in the dark at ambient temperature, and the absorbance was measured at 765nm after using UV-vis spectrophotometer (Shimadzu, Model UV-160A, Tokyo, Japan). The result of total phenols content was expressed as gallic acid equivalents (GAE/g of TPP), using the calibration curve of gallic acid.

Flavonoid amount was measured according to a colorimetric method using Aluminum chloride (Bahorunet *al.*, 1996). A volume of 1 ml of 2% aluminum chloride was added to methanolic plant extract. The sample remained at room temperature for 10 min; and the absorbance was measured at 430 nm using UV-vis spectrophotometer (Shimadzu, Model UV-160A, Tokyo, Japan). Total flavonoid content was calculated using a quercetin calibration curve and expressed as mg quercetin equivalents per gram of TPP.

### ***Lycopene analysis***

Lycopene was extracted and analyzed conforming to the method used by Dembélé *et al.* (2019). A sample of peel powder was macerated with 10 mL of solvents (hexane / acetone / ethanol, 50/50/1, V /V /V). After that this mixture was mixed for 10 min and centrifuged at 5000 rpm for 15 minutes. Finally, the organic phase was recovered and diluted in 10 mL of hexane. Absorbance of this solution was measured at 472 nm using hexane as blank. Lycopene concentration was calculated using the following equation:

Lycopene content (%): =  $(\text{Abs } 472 \times \text{Fd} \times 10^5 \times \text{V}) / 3450 \times 100 \times \text{m}$ , where Fd: Dilution factor, V: Volume of extraction solvent, 3450: Extinguishing coefficient of hexane, and m: Weight of the test sample. The concentration of lycopene was expressed as mg/100 g dry weight (fw).

### ***DPPH radical scavenging activity***

The antioxidant test was determined with the DPPH method of Sanchez-Moreno (1998). 50µl of the methanolic extract prepared at different concentrations (from 0.0125 to 5mg/ml) are added to 1950 µl of the methanolic solution of DPPH (0.025g/l). Then, a negative control is prepared by mixing 50µl of methanol with 1950 µl of the methanolic solution of DPPH. After 30 min of incubation in the dark and at room temperature, the measurement of absorbance is done against a blank prepared for each concentration at 515nm. The positive control is represented by a standard solution of ascorbic acid whose absorbance was measured under the same conditions as the samples. The results were expressed as percentage of inhibition (I%).  $I\% = [(\text{Abs control} - \text{Abs test}) / \text{Abs control}] \times 100$ .

Where Abs control is the absorbance of the control, Abs test is the absorbance of the sample.

### ***pH of meat measurement***

The pH value of lamb patties was determined employing the method provided by Tareq *et al.* (2018). A sample (10g) was mixed with 50 ml of distilled water using a vortex machine for 1 min and the pH was measured using a digital pH-meter.

### ***Determination of lipid oxidation***

Lipid peroxidation in lamb meat patties was determined according to Genot (1996) method. Briefly, a sample (2g) was homogenized with 16 ml of a 5 %

(w/v) aqueous solution of trichloroacetic acid (TCA) (Sigma-Aldrich Co., St., Louis, MO) and 100 µl of vitamin C by using a homogenizer. After filtration, 2 ml of the filtrate was mixed with 2 ml of TBA (20 mol/L) in test tubes, and they were placed in a water bath set to 70°C for 30 min. After cooling under tap water, absorbance of the mixtures was read at 532 nm using a spectrophotometer. Results are obtained using the following equation: MDA (mg/kg of sample) =  $[(0.72/1.56) \times (A_{532} \times \text{Solvent volume} \times \text{Filtrate volume}) / \text{sample weight (g)}]$ .

### ***Statistical analysis***

Results were analyzed using SPSS software version 19. Parametric values were compared with Duncan's multiple range test. Statements of statistical significance are based on ( $p < 0.05$ ).

## **Results**

### ***Phytochemical analysis and antioxidant capacity***

The total polyphenol content, total flavonoid content, lycopene concentration and antioxidant activity of analyzed TPP were presented in Table 1. The results found reveal that the total content of TPP is  $168.20 \pm 0.04$  mg GAE /100g of dry weight. In this work, we also found that TPP presents a flavonoids content of  $22.67 \pm 0.09$  mg QE/100 g of dry weight. Tomato peel used in this experiment showed a high lycopene concentration  $2.13 \pm 13.02$  mg/100 g of dry weight and it had a good DPPH radical scavenging activity which was  $45.62 \pm 0.09$  %.

**Table 1.** Total phenols, flavonoids and lycopene concentrations and DPPH scavenging activity of TPP

|     | TPC (mg GAE /100 g) | TFC (mg QE /100 g) | Lycopene (mg/100 g) | DPPH scavenging (%) |
|-----|---------------------|--------------------|---------------------|---------------------|
| TPP | $168.20 \pm 0.04$   | $22.67 \pm 0.09$   | $2.13 \pm 13.2$     | $45.62 \pm 0.09$    |

TPC—total phenols content, TFC—total flavonoids content, DPPH— antioxidant activity measured by DPPH assay. The values represent the mean of five individual repetitions ( $n = 5 \pm \text{SD}$ ).

### ***Effect of tomato peel powder on meat pH evolution***

The present results (Table 2) demonstrate that the pH value of fresh lamb meat patties (day 0) reduced significantly ( $p < 0.05$ ) with the increasing of TPP concentration in the samples ( $5.77 \pm 0.08$  from the C against  $5.55 \pm 0.05$  from the

T3 samples). Moreover, during the refrigeration the pH values for all treatments significantly ( $p<0.05$ ) increased, but this rise is much greater in the control samples as compared to those containing TPP with different concentrations ( $6.18 \pm 0.06$  from the C against  $5.69 \pm 0.06$  from the T3 samples). A non-significant interaction was concluded between the factors studied on the pH values of meat lamb patties.

**Table 2.** Effect of TPP concentration on pH values of lamb meat patties during storage

|    | Storage<br>time (days) | Treatment         |                   |                   |                   |
|----|------------------------|-------------------|-------------------|-------------------|-------------------|
|    |                        | C                 | T1                | T2                | T3                |
| pH | 0                      | $5.77^a \pm 0.08$ | $5.68^b \pm 0.04$ | $5.62^b \pm 0.04$ | $5.55^c \pm 0.05$ |
|    | 6                      | $5.94^a \pm 0.04$ | $5.87^b \pm 0.03$ | $5.74^c \pm 0.03$ | $5.62^d \pm 0.03$ |
|    | 12                     | $6.18^a \pm 0.06$ | $5.96^b \pm 0.02$ | $5.86^c \pm 0.04$ | $5.69^d \pm 0.06$ |

The values represent the mean of five individual repetitions ( $n = 5 \pm SD$ ), means followed by different letters illustrate significant differences ( $p<0.05$ ).

#### *Effect of tomato peel powder on TBA value*

Results showed that the TBA value of all samples of lamb meat patties either those of the control or the other treatments increased significantly ( $p<0.05$ ) during the storage (from 0.23 to 0.44 mg MDA/ kg in the C samples and from 0.22 to 0.29 mg MDA/ kg in T3 samples) (Table 3). however, the highest TBA value was found in the control samples, lamb meat patties from the T3 (containing 3% of TPP) showed significantly ( $p<0.05$ ) the lowest TBA value (0.29 mg MDA/kg) succeeded by T2 and T1 samples with (0.32 and 0.38 mg MDA/kg) respectively.

**Table 3.** Effect of TPP concentration on TBARS values (mg MDA/kg) of meat patties

|       | Storage<br>time (days) | Treatment         |                   |                   |                   |
|-------|------------------------|-------------------|-------------------|-------------------|-------------------|
|       |                        | C                 | T1                | T2                | T3                |
| TBARS | 0                      | $0.23 \pm 0.05$   | $0.23 \pm 0.02$   | $0.22 \pm 0.03$   | $0.22 \pm 0.03$   |
|       | 6                      | $0.31^a \pm 0.03$ | $0.29^b \pm 0.07$ | $0.26^c \pm 0.01$ | $0.25^c \pm 0.05$ |
|       | 12                     | $0.44^a \pm 0.02$ | $0.38^b \pm 0.01$ | $0.32^c \pm 0.02$ | $0.29^d \pm 0.02$ |

The values represent the mean of five individual repetitions ( $n = 5 \pm SD$ ), means followed by different letters illustrate significant differences ( $p<0.05$ ).

## Discussion

The results of antioxidants activities showed that tomato peel presented high potential antioxidant. Phenolic compounds present in all parts of the plant are essential for its development, serving as antibiotics and natural pesticides (Gupta and Sharma, 2014). Our finding of TPC was in line with those found by Navarro-González *et al.* (2011), in their study the content of TPC of tomato peel fiber was 158.10 mg GAE/100 g. In addition, Vadez-Morales *et al.* (2014) found that tomato peel from several tomato types showed high levels of phenolic content. The variations were from 71.6 to 351.6 mg GAE /100 g peel samples. Our result of TFC was consistent with that indicated by Darwish *et al.* (2019); they noted in their study that tomato peels contain 0.97 mg/g of flavonoids. In addition, Stewart *et al.* (2000) stated that the skin of tomatoes contains the principal part of the flavonoids. The flavonoids contained in tomato peel (quercetin, naringenin and rutin) have beneficial effects for human health. (Navarro-Gonzalez *et al.*, 2011).

Tomato wastes are known to be the richest in lycopene compared to the other agro-industrial by-products (Kong *et al.*, 2010). Knoblich *et al.* (2005) indicated that peel by-product contains a larger quantity of lycopene than the seed byproduct, its content in their study was 734 µg/g of dry material. The lycopene content in our study was close to the findings of Navarro-González *et al.* (2011) who used three extractions methods of lycopene: enzyme hydrolysis, maceration, and ultrasonic assistance, and obtained that the concentration of lycopene in commercial tomato peel varied between 3 and 4 mg/100 g. Hence, our result remained lower than those found by Chandra *et al.* (2012), in their experiment, the lycopene content of skins separated from 15 commercially tomato genotypes ranged from 5.32 to 24.08 mg/100g.

The DPPH scavenging activity found in our study was in agreement with the reports of Elbadrawy and Sello (2016) who demonstrated that tomato peel possesses antioxidant activity due to its higher content of lycopene and phenolic compounds; indeed, it can scavenge free radicals.

pH value is considered as an important factor that affects meat quality and influences on many characteristics such as shelf life, color, water holding capacity and texture of meat and meat products (Clarke *et al.*, 1998). The pH values in this work decreased significantly ( $p < 0.05$ ) due to the incorporation of tomato peel powder in fresh lamb meat patties. The same observation was made by Salem (2013) who added 3 and 6% of dry tomato peel in beef sausage, in their study, the pH value of fresh sausage samples ranged from 5.10 to 5.61. This result may be explained by the acid pH values of dry tomato peel used (García *et al.*, 2009). In addition, the refrigerated storage caused a significant increase in pH

results of lamb meat patties. Our findings are similar to those reported by Almasriet *al.* (2019) who demonstrated that the bacterial action in meat leads to the accumulation of metabolites and desaminations of proteins which increases the pH.

Lipid oxidation is an important factor that can limit the quality and the acceptability of meat and meat products. Thiobarbituric acid (TBA) value (malonaldehyde mg/ kg) is used as an index for measuring oxidative rancidity which appears in meat products during storage (Hussein *et al.*, 2019). In our study, TBA value of all treatments revealed a significant rise ( $p<0.05$ ) during the refrigerated storage, but the use of tomato peel powder caused a significant reduction ( $p<0.05$ ) in lipid oxidation especially with the concentration of 3%. These findings were consistent with those obtained by Salem (2013). Almasriet *al.* (2019) found that the use of natural extracts of tomato peel and potato peel in the lamb slices had lower TBARS values than the control samples during the storage time. In their study, tomato peel extract successfully reduced the oxidation processes and the peroxide value and it showed comparable effect to industrial antioxidants BHT. Ammar and Aboalfa (2017) also noticed that the TBA values were decreased with increasing tomato peel powder incorporation level (1, 2, 3 and 4%) in chicken burger during frozen storage for 90 days, and they reported that these findings may be explained by the polyphenol content of tomatoes peel powder that reduces the oxidative reaction of lipids.

This study demonstrated that tomato peel powder is rich in polyphenols and flavonoids compounds and it can be concluded from these results that the incorporation of tomato peel powder at 3% in lamb meat patties stored at 4°C for 12 days showed a good antioxidant activity which reduced the lipid oxidation. Therefore, this peel can be used in other food products for improving quality; and it can also be exploited in the pharmaceutical industry as a source of antioxidants.

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### **Conflicts of interest**

The authors declare no conflict of interest.

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