Tomato Waste as a Source of Biologically Active Compounds

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Abstract

Large amounts of wastes are generated annually by the vegetable processing industry, their efficient management and valorization representing a priority research area. Recent research suggested the possibility of reusing tomato pomace as a cheap source of many bioactive compounds, such as antioxidants, soluble dietary fibers and vitamins. The high initial moisture of fresh tomato pomace and the presence of considerable levels of nutrients make this waste susceptible to microbial degradation. Therefore, the fresh pomace of three tomato varieties were preserved by two different methods and then analyzed regarding the total phenolics content, flavonoids, lycopene and antioxidant activity. The results showed that all samples contained considerable amounts of phenolic compounds and exhibit good antioxidant properties. A higher lycopene content was obtained for dehydrated samples, other similar studies explaining that heat processing can breakdown the cellular walls and the chromoplast membranes, leading to a better release. The obtained results highlight the potential of reusing tomato processing waste as source of bioactive compounds and encourages the implementation of a sustainable valorization plan.

Keywords: *bioactive compounds, lycopene, phenolic compounds, tomato waste, valorization*

Introduction

Nowadays, increasing efforts are being directed towards the exploitation of agro-industrial waste, from both economic and environmental standpoints. These by-products are recognized as having significant amounts of biologically active compounds while their uncontrolled disposal lead to environmental problems. Also, the evidence relating to decreased prevalence of chronic heart diseases, atherosclerosis or other diseases caused by oxidative stress, through a diet rich in antioxidants, has oriented scientific research towards the exploitation of fruits and vegetables waste in order to discover new sources of natural phytochemicals that could be further incorporated in foods, cosmetics and pharmaceuticals (Socaci et al., 2017; Lu et al., 2019).

Tomato (*Solanum lycopersicum*) is one of the most widely cultivated vegetable crop, with a world production of over 168 million tons in 2016. As a seasonal fruit, only a part of the production is consumed as a fresh commodity, more than 40 million tons being processed to produce tomato paste, juice, sauces, puree, ketchup or canned tomatoes (FAO 2017; WPTC 2018).

During the processing of tomatoes, the main generated waste is the tomato pomace, a mix of tomato peel, seeds, fibrous part and a small fraction of the pulp. The amount of pomace can vary from one processing plant to another, due to the processing conditions and raw material varieties, and has been reported to account up to 7.5% of the original plant, thus representing

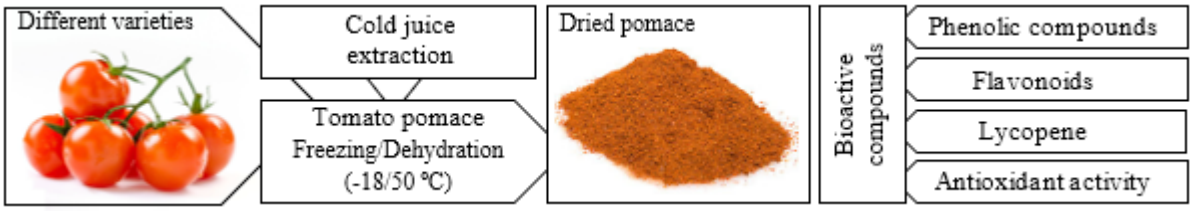

Figure 1. The experimental design applied for the analysis of tomato waste

approximately 2 million tons of disposed organic matter (Silva et al., 2018).

Currently, this by-product is mainly disposed in the landfill or used as animal feed, but its chemical composition suggests the possibility of reusing tomato pomace as a cheap source of many high value bioactive compounds, such as natural antioxidants, soluble dietary fibers and vitamins (Grasino et al., 2016; Nour et al., 2018;).

The proximate chemical composition of tomato pomace at different stages of industrial processing showed an average composition of 59.03% neutral detergent fiber, 25.73% total sugars, 19.27% protein, 7.55% pectin, 5.85% lipids and 3.92% mineral content on a dry weight basis (Szabo et., al 2018). Tomato pomace was also reported to be an excellent source of antioxidants including carotenoids, phenolic compounds, ascorbic acid, which are widely recognized as having strong radical scavenging properties. In a recent study, Nour et al. (2018) stated that dried tomato wastes contain considerable amounts of lycopene (510.6 mg/kg) and β-carotene (95.6 mg/kg) and exhibit good antioxidant properties. They also reported a total phenolics average of 1229.5 mg GAE/kg, of which flavonoids accounted for 415.3 mg QE/kg.

Lycopene is the main carotenoid found in tomatoes, accounting for 80–90% of the total carotenoids, but other carotenoids such as α-, β-, γ-, δ-carotene, phytoene, and lutein are also present. The importance of this compound is scientifically supported, many studies suggesting that a direct correlation may be established between the consumption of foods rich in lycopene and a low risk of prostate cancer and cardiovascular diseases (Socaci et al., 2017; Song et al., 2017).

Considering the worldwide presence of the tomato canning industry and the significant quantities of waste generated, it is essential to develop a detailed characterization of tomato waste in order to highlight its potential in developing new ingredients and functional products.

In this sense, this research evaluated, *in vitro* antioxidant capacity, total phenolic content and lycopene content of tomato pomace, to assess the potential of reusing this residue as source of nutrients, bioactive compounds or as a functional ingredient for food applications.

Materials and Methods

The samples taken into the study were imported cultivars, purchased from a local supermarket (Cluj-Napoca, Romania) at commercial maturity – cv. Roma from Spain (R-ES), cv. Cherry from Turkey (C-TK) and cv. Dutch from Netherlands (D-NL).

The high initial moisture content of fresh tomato pomace and the presence of considerable levels of nutrients make this waste susceptible to microbial degradation within a few days. Therefore, after the juice extraction, the resulted fresh pomaces were preserved in two ways: by drying at 50^0C/6h using a food dehydrator Biovita - DEH 600 and by freezing at -18^0C after homogenization and vacuum sealing in polyethylene bags. For each sample the content in total phenolics, total flavonoids, lycopene and antioxidant activity were performed in triplicate and the obtained results (dry weight reported) were expressed as mean ± standard deviation. All the solvents/chemicals obtained from Sigma Aldrich or Merck (Germany) were of analytical grade or high-performance liquid chromatography grade.

Total phenolics compounds were determined spectrophotometrically using a modified Folin-Ciocalteu method (Singleton et al., 1999). Flavonoids quantifications was accomplish using a chromogenic system of $NaNO_2$–$AlCl_3$–NaOH, according to the method described by Zhu et al., 2010, and for the antioxidant activity the DPPH method was used (Odriozola et al., 2008). The total

lycopene content of each tomato pomace sample was determined using a rapid spectrometric technique, as proposed by Socaci et al. (2014), for tomato and tomato products. A mixture of butylated hydroxytoluene (0.05% in acetone, w/v), ethanol and hexane (1:1:2) was used for the extraction and the absorbance of the upper hexane layer was measured at 503 nm. All spectrophotometric measurements were performed using a Shimadzu UV-1700 Pharma Spec spectrophotometer.

Results and discussion

In broad terms, the results presented in table 1 state that all the analyzed samples contain considerable amounts of phytochemicals and exhibit good antioxidant properties, depending on the tomato cultivar and preservation method.

The total phenolic compounds of tomato pomace extracts varied between 148 and 202.21 mg GAE/100 g of dw, of which flavonoids accounted for 22.0 and 41.54 mg QE/100 g dw, similar results being reported by Silva et al. (2018). The highest concentrations of phenolics was obtained for Cherry variety pomace (202.21 mg GAE/100 g dw), while for the flavonoids, Dutch pomace had the highest level (41.54 mg QE/100 g dw). These values vary widely, depending on the initial content of the tomato's varieties, without significant differences between the applied conservation methods.

Consistent with other similar studies (Silva et al., 2018; Nour et al., 2018), the obtained results confirmed that tomato wastes contain considerable amounts of lycopene, with values between 42.18 and 70.03 mg/100 g dw. In this regard, Cherry pomace registered the highest values, for both frozen and dehydrated samples. A significantly higher lycopene content was obtained for dehydrated samples, for all three varieties taken into study. This may be due to the fact that heat processing can breakdown the cellular walls and the chromoplast membranes, leading to an increased bio accessibility of lycopene (Jamal et al., 2016). Lin and Chen (2003) also suggested that an increased temperature improves the lycopene bioavailability from the cell structure matrix. Therefore, it can be concluded that, compared to the freezing procedure, dehydration has led to an increase in the yield of lycopene extraction. The use of preservation by dehydration also has the advantage of reducing the volume of pomace without negatively modifying the chemical identity, while freezing is less efficient from this point of view and involves higher storage, transportation and processing costs.

The tomato waste samples exhibited good antioxidant properties, with values ranging from 16.57 to 29.14%, the scavenging free radicals activity being directly corelated with the amount of lycopene and phenolic compounds.

During the industrial canning of tomatoes, a considerable part of the phenolic compounds and lycopene are retained in the pomace, in the steps of peeling and juice extraction, since most of these compounds are originally located in the peel and seed fractions of the plant. This explains the high levels of antioxidant of tomato waste and the increased interest shown for its efficient exploitation.

Table 1. Total phenolics, total flavonoids, lycopene content and antioxidant activity of frozen (f) and dehydrated (d) pomace of the three tomato varieties (values are expressed as mean ± s.d.)

Investigated parameters (d.w. reported)	Roma - Spain		Cherry - Turkey		Dutch - Netherlands	
	R-ES-f	R-ES-d	C-TK-f	C-TK-d	D-NL-f	D-NL-d
Total phenolics, mg GAE/100 g	151.14 ± 1.7	148.0 ± 2.05	193.1 ± 1.26	202.21 ± 2.61	164.06 ± 0.94	175.43 ± 1.33
Flavonoids, mg QE/100 g	32.02 ± 0.56	29.15 ± 0.75	22.94 ± 0.92	22.00 ± 1.01	40.03 ± 1.04	41.54 ± 0.42
Lycopene mg/100 g	42.18 ± 1.08	58.35 ± 2.12	54.12 ± 0.96	70.03 ± 1.61	49.3 ± 0.44	65.91 ± 1.02
Antioxidant activity, %	16.57 ± 0.8	18.31 ± 0.12	24.22 ± 1.03	29.14 ± 0.71	19.3 ± 0.22	23.11 ± 0.5

Conclusion

The obtained results highlight the potential of reusing tomato processing waste as a reliable source of bioactive compounds and promote the implementation of a sustainable recycling plan for the development of new generation of functional ingredients and natural additive.

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