A case study of Italian tomato processing industry: a comprehensive evaluation from production, water, and energy consumption to waste valorization, and LCA point of view

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Keywords: tomato processing industry, waste valorization, tomato processing by-products, water-energy nexus, LCA.

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Food processing industries typically require a substantial amount of water and energy and generate large amount of wastes. Among the food industry, the tomato processing industry can be considered as one of the most important ones all over the world. Among the food industry, tomato processing industry consumes significant quantities of water and energy (thermal and electrical).

In terms of global production, around 180 million tons of tomatoes are produced each year (FAOSTAT, 2019), of which about 80% are processed to obtain products such as peeled tomato (whole, diced, or sliced), paste, juices, sauce, and ketchup (Arnal et al., 2018; Pataro et al., 2020). Among the 10 top countries for the tomato processing industry, Italy occupied the second position in the world and the first position in the Europe (https://www.tomatonews.com).

Generally, tomato processing industry consumes substantial quantities of water and energy (thermal and electrical) which are often linked to each other, given that energy is required to transport, heat, and cool water. Further, water in the form of steam may be used to generate thermal energy (Liu et al., 2019). These relationships are known as the water-energy nexus (WEN). (Hamidov et al., 2020). To understand how these resources are used in tomato processing and what are the existing opportunities to improve their efficient use, WEN assessment should be conducted to account for the different ways energy is embedded in water during tomato processing as energy consumed in motors, pumps, fans and boilers (Amon *et al.*, 2017).

On the other hand, tomato processing industries generate a huge amount of wastes, which mainly consists of wastewater and solid wastes. The latter include, among others, green tomato and especially tomato pomace (i.e., peels and seeds), which currently find low-added value uses as animal feed or compost (Strati et al., 2014), or are directly sent to landfills (Rossini et al., 2013). However, previous researches revealed that tomato pomace still retains a large amount of valuable compounds, such as natural carotenoid (e.g., lycopene, β-carotene) and phenolic compounds with high antioxidant activity, as well as proteins, cutin, pectin, oil and fibers, which are of noticeable commercial interest for their wide range of applications in food, pharmaceutical, and cosmetic industry (Pataro *et al.*, 2020). Therefore, the valorisation tomato wastes, could contribute to improve the economic, environmental, and social sustainability of tomato processing industry.

In this work, preliminary results achieved in the frame of the European project AccelWater (Project ID: 958266) and related to the assessment of water, energy and wastes at the different steps of a tomato processing company as well as their environmental impact, will be presented.

To reach this goal, an Italian tomato processing company receiving about 56,000 tons/year of fresh tomatoes, which are transformed in two different processing lines to produce about 27,000 tons/year of peeled tomato (whole and diced), and about 13,700 tons/year of tomato sauce. Overall, these two processes involve an annual total consumption of water, electrical energy, and methane of 88,000 m^3/year, 3,300 MWh/year, and 800,000 m^3/year, respectively. Moreover, they generate a total amount of tomato wastes (peels, seeds, green tomato, leaves, branches) of 5,400 tons/year, a total amount of sludge of 8,300 tons/year and 62,000 m^3/year of wastewater.

A detailed description of the two processing lines existing at Italian company is provided, and a corresponding Current Value Stream Map (CVSM) has been developed to identify the most relevant processing steps for water and energy consumption (thermal, electrical) and waste generation (wastewater and tomato processing wastes). The Key Performance Indicators (KPIs) are also estimated. Moreover, a water stream network map of tomato company is described and used to identify the WEN points and perform the WEN analysis. Finally, water, electrical and thermal energy usages for WEN, as well as for tomato proceeding wastes, is also reported. The results showed that, most of the water used, which amounts to up 70% of total fresh water, is pumped to flumes to unload, wash, sort, and convey tomatoes as they enter the facility. The remaining part of total fresh water was divided in cooling, vacuum pumps, boilers and CIP, respectively. Regarding the consumption of the total electrical energy, it has been found that about 1,400 MWh/season (43%) is used within the electrical WEN. Most of this energy (approximately 80%), is used for pumping operations, while the remaining amount is used to power fans, separators, and aerators. On the other hand, it was found that the thermal energy (steam) was unevenly distributed between the thermal units, being intensively consumed in both pasteurization and evaporation/concentration processes, and to a lesser extent, in peeling and hot break. In addition, the evaluation of waste generation during tomato processing showed that, as expected, the majority of the solid waste in the form of sludge and green tomatoes was generated during washing and sorting stage, which also generated the peeling and juice extraction phase. Finally, results of LCA study, “from gate to gate” approach, revealed that packaging is the main contributor to most of the impact categories.

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