Ph.D. COURSE IN INDUSTRIAL ENGINEERING
XXXIV CYCLE

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Title of the thesis

Valorization of tomato industrial by-products in Campania region for sustainable recovery of active compounds and biogenic fuels

Abstract of the thesis

Italy is the 2nd country in the world for tomato transformation after USA, due to 5 million tons of processed fresh fruits every year [1]. The Campania Region, due to its long-standing experience, is the main and biggest production pool regarding the transformation of tomato in Europe; it is reported [2], [3] that companies, operating in this region, process almost half of the Italian tomatoes for industry, namely 2.2 Mton of fresh fruits transformed every year.
The transformation of tomato leads to a huge amount of residues, namely peels, seeds and tomato pomace. These residues can represent even the 10% in weight of the processed tomato, with a high moisture content in the range 69-90 % by weight. Considering these data, it is estimated that 64 kton of tomato by-products are produced every year in Campania. However, their generation concentrates in only two months, according to the seasonality of the tomato supply chain.
Tomato pomace is composed by a mixture of pulp, skin, and seeds, carrying an enormous content of high-value compounds as carotenoids in the extractive, pectin and cutin (mainly in the peels), and glycerides (mainly in the seeds). These by-products are classifiable as a lignocellulosic biomass. Unfortunately, these residues are disposed of without any income for the tomato transformation companies, that is as animal feed or in the worst case sent to landfill, thus wasting high-value compounds and contributing to earth pollution. In principle, tomato processing by-products could be exploited through thermochemical, biological and chemical conversion to obtain biogenic fuels and then electricity and heat. Anyway, it is undoubtedly convenient to extract and recover, before conversion, the high-value compounds present in the pomace. A literature study carried out revealed 3 main components of interest: i. Lycopene, which is the most abundant carotenoid in peels and is well known to be the most a powerful antioxidant with beneficial effect on cancer and cardiovascular disease [4], [5]; ii. cutin, which is the main building block of the plant cuticles and it can be used as

starting material for biopolymers; iii. pectin, which is another building block of the cuticle of fruits and can be used in food processing. As a side work, a careful study on funded European projects regarding the management of tomato wastes was carried out, assessing and reporting about their scientific and technical results. Moreover, the interconnection among them was highlighted by focusing on the contribution that they gave to the European know-how, the management of these by-products and the progress they reached on waste minimization and valorization. Finally, the industrial and environmental outcomes of these projects have been reported by highlighting issues and problems that are still to be overcome

Considering this background, this work focused on the valorization of tomato by-products of Campania industries for the recovery of both added-value compounds and energy by making recourse to the "biorefinery cascade approach", namely a set of integrated unit operations that, while extracting the most valuable components from biomass first, leads to sustainable co-production of energy, fuel and high-value chemical compounds, with minimal generation of waste. As show in figure, a first outcome of this work was a brief block diagram for a multi-products biorefinery based on tomato by-products. In the first instance, a brief economic evaluation was carried out in order to demonstrate the importance that tomato residues could have in Campania economy and to estimate the added value that every year is wasted.

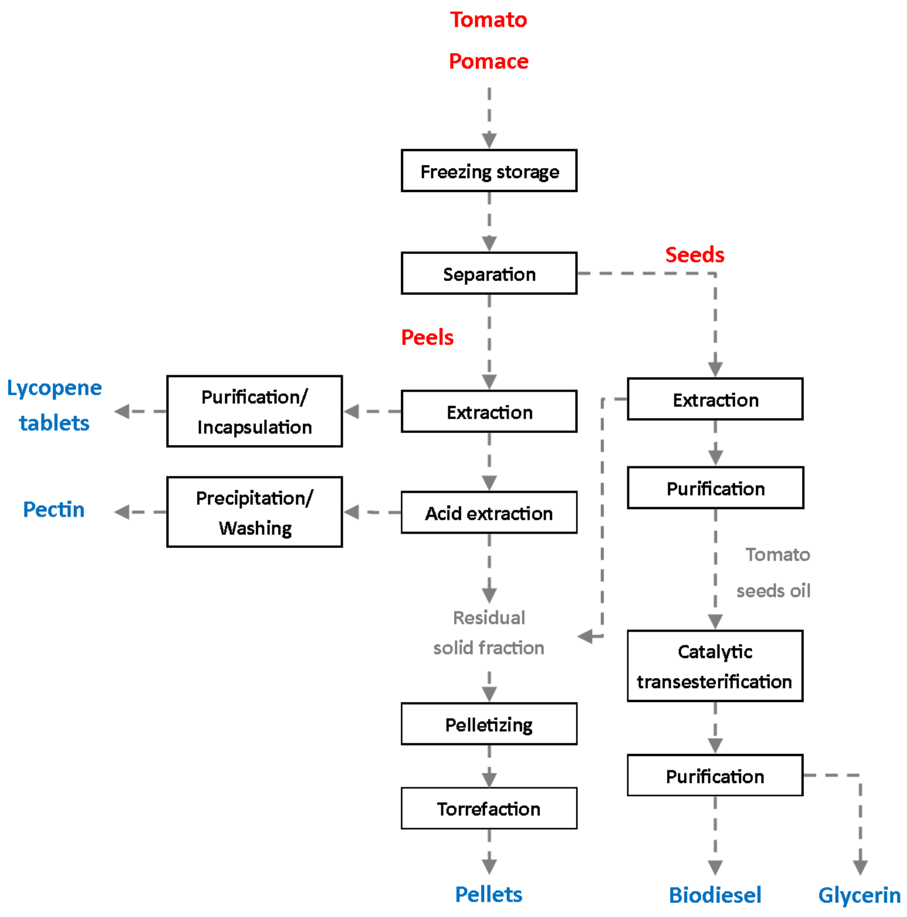

Figure 1 Biorefinery scheme for valorization of tomato processing by-products

The multi-product biorefinery scheme was divided in operating blocks, like tomato pomace separation, lycopene extraction, biodiesel production and so on. For each operating block two alternatives were selected from literature, one typical and commercially available, and the other one less studied and 'green'. Then, each alternative was studied, modelled and optimized to check the tecno-economic feasibility. Microsoft Excel ® and when possible Aspen Plus ® was used to evaluate mass and energy balances of the different operative blocks. Economic indexes, as gross profit and return of investment, were used to assess the economic feasibility of each biorefinery section and to compare different alternatives. In general, results show that valorizing tomato by-products with

cascade approach is technically feasible; moreover, the economic sustainability is always guaranteed, both for the commercial and the 'green' alternatives.
Finally, the Life Cycle Assessment was carried out to quantitatively assess the environmental impacts of two alternative biorefinery schemes, one based on the conventional techniques and another one on the 'green' alternatives. Then, two different scenarios were modeled for comparing the actual situation, namely how tomato pomace is disposed of, with the two developed biorefineries. LCA results shows that both biorefineries perform better than the actual scenario in all categories except in the ozone depletion and slightly in ionizing radiation. Conventional biorefinery performs worse than the actual scenario also in cancer effects, climate change and marine eutrophication. In general, the average reduction is 15.4% for conventional biorefinery and 39.7% for alternative biorefinery. This result suggests that, from an environmental perspective, processing tomato pomace in an alternative biorefinery is better than the actual situation. Chosing a conventional strategy would be less effective, even if it is worth noticing that products output is higher in this case.

References

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