Integrated design of a sustainable mobile fruit & vegetable processing unit

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The design of batch food processing plants is a complex problem where choices must be made at different scales (roughly product, process, plant) and according to different objectives and constraints. Multi-objective optimization (MOO) methods represent a relevant way to solve such problem, however it seems that in the food sector, it has not yet been used to its full potential (Madoumier, 2019).

In this case study, a mobile fruit & vegetable mobile processing unit aimed at reducing post-harvest losses in the context of sub-Saharan Africa was developed. This mobile unit is required to produce 4 products from thermally stabilized fruit and vegetables. In order for the mobile unit to be sustainable in this highly-constrained context, its efficiency is assessed according to 14 performance indicators, and the different design solutions are simulated with a multi-scale model and analyzed.

To develop the model and perform the optimization of the mobile plant, a design methodology called “Methodology for the Integrated, Multi-scale and Multi-Objective Design of Systems” (MIMMODS) was followed. This methodology consists of six successive tasks leading to the construction of a decision support tool. The tasks constitute a guide to ensure that the decision support tool is able to (i) simulate the behavior of the processing unit at different scales and estimate its performance, (ii) take into account user preferences in the implementation context, and (iii) search for the design solution(s) that best satisfy the design objectives and the preferences, according to the principles of MOO.

An optimization algorithm was used to find a design solution that met most of the constraints. The decision support tool helped better understand the design problem, and a prototype was built based on the design solution, which confirmed the relevance of the chosen solution.