EXERGY AS A TOOL FOR THE ANALYSIS OF FOOD CHAINS

Filippos K. Zisopoulos, Francisco Rossier-Miranda, Atze Jan van der Goot, Remko M. Boom

Introduction

A significant amount of the food produced currently is wasted along the food supply chain (Figure 1) (Gustavsson *et al.*, 2011). Therefore, more sustainable ways in producing and handling food have to be practiced in order to make the most optimal use of raw materials, of discarded (and potentially useful) streams and of energy and water usage. Certain tools can be used for the evaluation of unit operations and for the valorization of waste streams. However, one of the most common bottlenecks encountered in the assessment of sustainability of a given system is the objectivity of the method used.

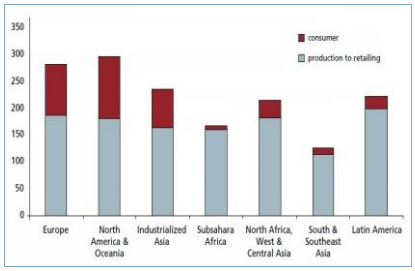

FIGURE 1: PER CAPITA FOOD LOSSES AND WASTE IN KG/YEAR ADAPTED FROM (GUSTAVSSON ET AL. 2011).

A qualitative and quantitative tool for such an assessment is exergy analysis which only recently made its way into the food industry (Apaiah *et al.,* 2006). This analysis can identify processes that are inefficient from an exergetic point of view even if they seem to be energetically efficient (Table 1).

TABLE 1. ENERGETIC AND EXERGETIC EFFICIENCIES OF PROCESSES ADAPTED FROM ROSEN & DINCER (1997) AND GAGGIOLI (1980).

Process	n_{en} (%)	n_{ex} (%)
Petroleum refining	90	10
Blast furnace	76	46
Residential heater	60	9

Exergy analysis compares a process with an ideal and infinitely slow process. Realistic time bounds can be taken into account by the use of finite time thermodynamics. In this way light can be shed on alternative routes for the minimization of the "price of haste" that we have to pay for a given process (Andresen, 2011).

Objective

The objective of this work package (WP2) is to extract a generic exergy based methodology for food chains. This methodology will be further extended by the concept of finite time thermodynamics.

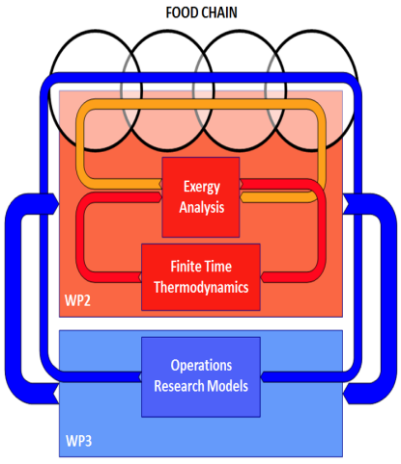

FIGURE 2: SCHEMATIC REPRESENTATION OF THE TOTAL PROJECT WHERE WP2: WORK PACKAGE OF FPE AND WP3: WORK PACKAGE OF ORL.

Approach

Selected cases of food chains will be studied by exergy analysis and alternative options will be looked at. The impact of those alternatives on the overall trade-offs in exergy destruction along the food chain will be assessed. Certain food processing unit operations will be analysed by applying finite time thermodynamics.

IN A NUTSHELL...

- Exergetic analysis of food chains
- Generalization of the methodology on different food chains
- Application of finite time thermodynamics on food processes
- Development of "greener" rules for redesigning food processes
- Cooperation with the ORL department. The goal is to develop of a tool for the food industry for easier decision making on sustainability issues

References

Andresen B., 2011, *Current trends in finite-time thermodynamics,* Angewandte Chemie – International Edition, 50, 12, pp. 2690-2704.

Apaiah R.K., Linnemann A.R., van der Kooi H.J., 2006, *Exergy analysis: A tool to study the sustainability of food supply chains*, Food Research International, 39, 1-11.

Gaggioli, R.A., 1980, *Second law analysis for process and energy engineering*, Paper Presented at the AIChE Winter Meeting, November, 1980.

Gustavsson *et al.*, 2011, *Global food losses and food waste: Extent causes and prevention*, Rome, FAO & SIK, Retrieved from http://www.fao.org/docrep/014/mb060e/mb060e00.pdf

Rosen, M.A., Dincer, I., 1997, *On exergy and environmental impact,* International Journal of Energy Research 21, 643–654.

TI FOOD NUTRITION
TI Food and Nutrition
P.O. Box 557
6700 AN Wageningen
The Netherlands
P +31 317 485 383
F +31 317 413 437
CONTACT:
filippos.zisopoulos@wur.nl
francisco.rossier@wur.nl
atzejan.vanderGoot@wur.nl

FOOD & BIOBASED RESEARCH
WAGENINGEN UR
Food Process Engineering department
P.O. Box 8129
6703 HD Wageningen
The Netherlands
F +31 (317) 482 884