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Title: **Reducing food losses requires more than technology**

Generation of food losses differs largely in developing and industrialized countries. In developing countries over 40% of the food losses occur at post-harvest and processing while in industrialized countries more than 40% of the food losses happen at retail and consumer levels (FAO, 2011). In total, low-income countries account for 44% of the food loss and waste (Lipinski et al., 2013). In low-income countries food losses in the first stages of the food supply chain, i.e. production, handling & storage and processing, are substantially higher than in high-income countries where most of the food losses occur at the end of the food chain (see Figure 1).

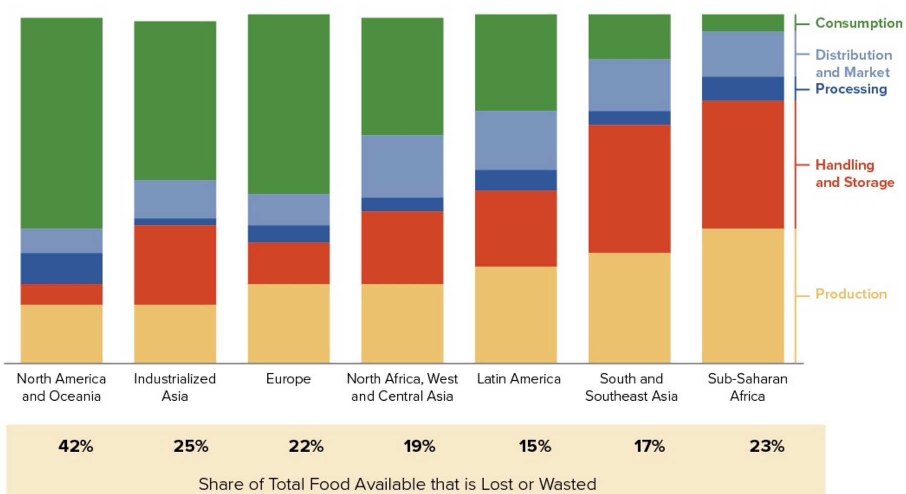

Figure 1: Share of Total Food Available (Kcal) that is lost or Wasted. Source: (Lipinski et al. 2013)

More specific estimates of food losses per product category (see e.g. Porter et al., 2016) confirm that in low-income areas for most product categories the loss percentages in agricultural production and post-harvest handling are relatively large. Gustavsson (2011) deduced that the causes of food losses and waste in low-income countries are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems.

In these first stages of the supply chain, we see that food losses are largely induced by pests and diseases, mechanical (handling) injuries, physical deterioration/aging, growth of spoilage micro-organisms and temperature initiated physiological mechanisms. The table below describes the primary and secondary causes that lead to the above mentioned reasons for food loss.

Table 1: types and cause food loss

Types	Primary cause	Secondary cause	Activity
Mechanical damage / physical damage	Damage, bruising, cracking. Rotting by fungal and bacterial pathogenies is often indicative of physical damage	'Wrong' use or absence of packaging and high temperature and relative humidity during harvest, storage and transport favour the development of post-harvest decay organisms.	Storage Transportation Post-harvest handling
Physio-biochemical loss / deterioration	Senescence or aging process (unavoidable): Transpiration, respiration, sprouting	Packaging can reduce the aging process providing ventilation to prevent dehydration, temperature rises, et cetera	Storage Transportation Post-harvest handling
Microbial spoilage or loss	Rotting caused by fungi, bacteria, yeast and moulds	High temperature and relative humidity during harvest, storage and transport favour the development of post-harvest decay organisms.	Storage Transportation Post-harvest handling
Physical rejection or loss	Injury in relation to 'wrong' or absence of refrigerated storage, temperature and relative humidity, composition and proportion of gases in controlled atmosphere storage, type of wrapper or packaging		Storage Transportation Post-harvest handling

Based on https://postharvest.nri.org/scenarios/fruit-and-vegetables, http://www.agriinfo.in/default.aspx?page=topic&superid=2&topicid=2046 http://www.fao.org/docrep/T0073E/T0073E01.htm#Foreword

Technological interventions for reducing food losses are oriented at preventing product damage and infestation, and postponing deterioration and microbial growth. Food loss is therefore most often linked to missing quality-oriented technological means, like refrigeration and advanced packaging.

Connected to that it is generally recommended to apply quality-oriented interventions at the beginning of the supply chain in order to minimise rapid quality loss. However, technological interventions often are not economic feasible at the small scale of the majority of farmers in low-income countries. Hence, either rapid collection to a collection centre (where larger volumes may allow technological interventions) and/or low-tech solutions are in place: even small temperature reductions may have significant effects further along the supply chain.

However, the success of technological interventions depends on the embedding in the specific supply chain context. Each situation requires tailor-made solutions. Many projects in less developed countries fail, not for technological or economic reasons, but because the project designers either ignored or oversimplified the social and cultural relationships existing in context to the area of implementation (Murphy, 2001). This is even more true in the case of projects focussing on implementation of technologies. For implementing the right technology you not only have to address the associated physical aspects of the technology ("hardware"), but also the organizational and economic ("orgware") and educational/scientific ("software") requirements of the supply chain as a whole. As Christiansen et al. (2011) and UNFCCC, (2013, 2014) stated, hard and soft technologies are often introduced in isolation, it has been recognised that their simultaneous integration with orgware is necessary for success in adaptation. Though all three technology types are necessary, there is a concern that hard technologies are currently prioritised and often employed in isolation (Christiansen et al., 2011; UNFCCC, 2014).

Furthermore, practical value of such effects depend on correct and consequent use in the formal supply chain, whereas economic feasibility depends on the added value generated in the market. Research showed (Seville et at, 2011) that formal chains tend to provide greater income security but not necessarily higher prices. When higher incomes do occur, it is often from higher yields, improved quality or value-added activities. Adding value by aligning technology along the chain is therefore essential. A cold chain should not be interrupted: when a cold product is placed in a warmer environment, in normal conditions moisture condensation will occur on the product, a suitable environment for mould growth. Furthermore, fruit products tend to ripen at elevated temperatures. Thus the orgware arrangements should be set up in parallel to the hardware development. Likewise, gas protective packages are designed for specific produce. Barrier properties are optimised for a product at specific temperature rage. Because a products respiration activity largely varies with temperature (and ripeness stage), applying the package at suboptimal conditions may have counterproductive effects.

Conclusion

Focusing on improved product quality throughout the entire supply chain in the fight against food waste in less developed countries has shown to be an effective approach. The use of (proven) technology can greatly accelerate this improvement. However, employing technology in isolation will not lead to the desired effect in the longer term. Simultaneous integration of hardware and software with orgware is necessary for success in adaptation. In addition, it will always be necessary that every investment in technology must ultimately be reimbursed by the recognized added value from the market.

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