Thesis title: A cradle-to-gate assessment of environmental impacts of mustard oil production using life cycle assessment approach

Abstract

The sustainability of agri-food systems has emerged as a global priority. They account for 20-35% of resources and energy consumption worldwide. Further, the concerns of their sustainability become aggravated in view of the increasing population and concomitant pressure on resources. They are facing an interconnected challenge of producing more food while minimizing the pressure on resources and consequent burden of environmental impacts. In view of the interrelatedness of challenges, taking up a systems approach to make shift in the agri-food systems becomes imperative. Indian edible oil sector, among all agriculture commodities, has witnessed a great transformation due to trade liberalization. More than half of the domestic consumption needs of edible oil are met through import. There is an immediate need to increase the domestic production of edible oils while minimizing the pressure on resources. This thesis applied Life cycle assessment (LCA) as a systems approach for cradle-to-gate assessment of environmental impacts of producing mustard oil following the methodological framework of ISO 14040. The goal was to identify the processes with significant environmental input-output flows i.e. the hotspots in mustard oil production. The study further evaluated the potential life cycle environmental impacts associated with different processing scales and methods of producing mustard oil. The effect of allocation choices on overall environmental impacts has also been analysed. The assessment was performed at both midpoint and endpoint levels using ReCiPe method. The LCA results clearly identified the agriculture stage as the hotspot having dominating share in all the environmental impact potentials (>95%). Within agriculture stage, the major contribution came from use of electricity, fertilizers production, field emissions, and transport of agriculture inputs. Inclusion of biogenic uptake of CO_2 from atmosphere during photosynthesis contributed in net benefits for the climate change potential impact category. In industry subsystem, small scale processing showed to have higher environmental impacts. In comparison to small-scale processing, the environmental impacts of medium and large-scale were reduced by around 4% and 8%, respectively. However, in large scale processing, the benefits of high oil extraction, and more efficient use of raw materials and energy were overshadowed by longer transport distances. In the comparison of environmental impacts of extraction methods, full pressing technology (FPT) showed lower impacts than solvent extraction combined with pressing technology (SEPT). Though, the percent difference in average environmental impacts was found statistically significant ($P < 0.05$). Further, the results were significantly influenced by the method

used for allocation of environmental impacts between products and co-products in both agriculture (seed and straw) and industry (oil and cake) subsystems. Overall, this study has provided the first comprehensive overview of the environmental impacts of edible oil systems in Indian conditions using life cycle approach. The results intend to be useful to future researchers in this area for estimation of the extent of implications under different scenarios. Finally, the finding of this study would facilitate policy makers a platform for reorienting the focus on optimization of edible oil systems rather than preferring one oil over another on the basis of price and trade benefits.