Circular Bioeconomy in the Food, Energy, and Environment Nexus

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Do we consume all the food that we produce? No. Post-harvest losses due to damage, poor storage conditions, rot, pests, and vermin account for 27 to 40% of total global food production. Minimizing post-harvest losses is thus important to ensure food security, the access to safe, nutritious, and affordable food, for a world population that is currently over 7.8 billion. And somehow, this must be achieved in a sustainable manner within the context of climate change, loss of biodiversity, increased demand for fuel, and the projected increase of the global population to 9 billion by 2040.

Post-harvest technologies for extending storage life, drying, heat treatment, and processing of foods can help to significantly lower post-harvest losses of crops and produce. The processing of surplus and unmarketable horticultural produce into food products such as juice, pastes, dried foods, and preserves captures the nutritional components of crops that would otherwise have been discarded.

Food processing methods using electro-technologies based on microwaves, radio-frequency and pulse electric fields have been developed for drying of produce and fruits, for thermal treatment of foods, for pasteurization of whole eggs, fruit juices, and other foods, and for disinfestation of grains. The advantage of using electro-technologies is that heating occurs volumetrically within the biomass and the limitations of heat transfer from an external source of heat are overcome. Heating is rapid; thus, the exposure time of the biomass to high temperatures is short, and the initial quality of the food material is better retained. The use of high voltage fields for the drying of foods with heat sensitive nutrients is being studied, as is the effect of such a process on protein structure and properties.

Electro-technologies have also been used in bioprocesses for the valorization of waste biomass from the agricultural, food, and forestry sectors. Methods for rapid and efficient microwave-assisted extraction of nutraceuticals and other bioactive components from plant biomass have been developed and optimized. Such methods are very efficient and use little solvent, and thus have less environmental impact than standard extraction methods. The use of electro-technologies has also been examined for the retting and dewatering of hemp and flax straws to obtain high quality fibers. Retting is a lengthy process in which the fiber bundles are separated from the lignocellulosic sheath in the straw, and which uses a lot of water. The application of this method to separate lignocellulosic materials into its components at the site of production has immense implication on the economic viability of bio-refineries. The savings in the cost of shipping that results from the transport of denser and purer fractions of feedstock to biorefineries for production of biofuels and chemicals will foster the growth of this nascent industry. Methods using microwaves are being developed for pyrolysis of organic wastes into biochar and bio-oils, and for hydrothermal carbonization (HTC) of wet biomass into hydrochar, a coal-like substance and bio-oils. Biochar and hydrochar can be used as fuels, as a means of sequestering carbon in a stable form, and as soil amendment to improve soil structure and productivity. The bio-oils can be used as fuel and as a source of valued chemicals. HTC has potential use for value addition to wastes from the fish and seafood processing industry.

Innovative bioprocessing technologies using electro-technologies are thus providing solutions for our food systems to maintain food security, safety, and nutritional quality for the world, while also addressing environmental concerns through value addition to waste streams of the agri-food sectors, and the increasing demands for alternate sources of fuels.