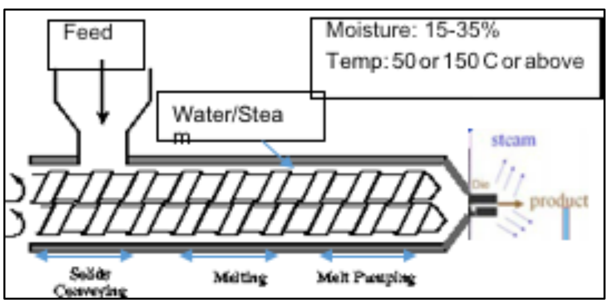
SCALE-UP OF SUPERCRITICAL FLUID-BASED EXTRUSION PROCESSES

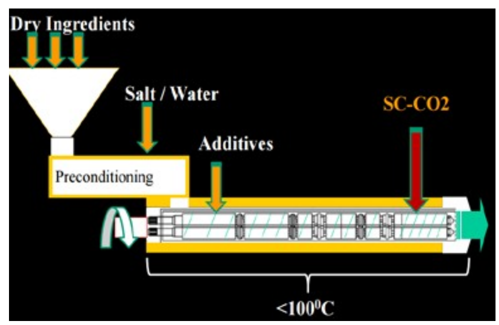
Proposed by Syed Rizvi, Department of Food Science

Conventional steam-based extrusion (SBX) process is a commercially practiced technology to produce a large variety of expanded food products. During SBX, a heterogeneous melt of starch and other ingredients undergoes a high-temperature (120-180^0 C), high-shear cooking where water acts both as a plasticizer for melt formation and a blowing agent for expansion. The harsh operating conditions of the SBX process often prevent effective utilization of formulations containing heat and shear sensitive ingredients. Steam-expanded products usually show non-uniform cellular structures and cell sizes. Supercritical fluid extrusion (SCFX) is a novel technology that uses supercritical carbon dioxide (SC-CO2) as a blowing agent, and hence formulations containing heat-sensitive ingredients can be employed to make expanded products at temperatures below 100^0 C. A higher moisture content (i.e., 30-45 wt.%) in the extruder barrel is utilized to keep the product temperature low via reduction of viscous dissipation of mechanical energy and to maximize SC-CO2 solubilization in the melt. The SCFX results in a more homogenous nucleation and uniform microporous structure.

Steam-based extrusion (SBX)



Supercritical Fluid Extrusion (SCFX)



However, the advantage of maintaining low temperatures to minimize thermal degradation of ingredients also poses a major engineering challenge in the process scale-up. When a supercritical extruder is scaled-up, the extruder volume is triples, whereas the cooling surface area just doubles, resulting in an inefficient cooling and high temperatures. The objective of this project is to perform energy studies on a supercritical twin-screw extruder as a function of its operating parameters to quantify and optimize the cooling efficiency needed for scale-up of the process.

JOULE-THOMSON COOLING FOR CRYOGENIC APPLICATIONS IN FOOD PROCESSING

Proposed by Syed Rizvi, Department of Food Science

Cryogenics engineering includes cooling and freezing of materials to very low temperatures using highly condensed gases like nitrogen, carbon dioxide helium, etc. In the food industry, liquid nitrogen is used to freeze foods quickly. In its liquid form, nitrogen, at -196°C, is one of the coldest substances that is often used to flash freeze fresh foods. As cryogenic freezing is much faster than mechanical freezing, products frozen with cryogenic technologies show a higher retention of water with a matrix of small ice crystals and retain their natural quality better.

Our current focus in this area involves Joule-Thomson expansion via adiabatic throttling which eliminates the need for elaborate mechanical refrigeration system and simplifies the equipment necessary. As the demand for value-added food product accelerates, there are many opportunities to further develop cryogenic technologies for food freezing and chilling applications. In particular, our group is engaged in designing and modeling a novel system that achieves instant freezing of products like ice cream and sorbet. Students working on this project need to be proficient in process modeling in ASPEN.