Economic Feasibility Study on the Supercritical Fluid Extraction of Edible Oils

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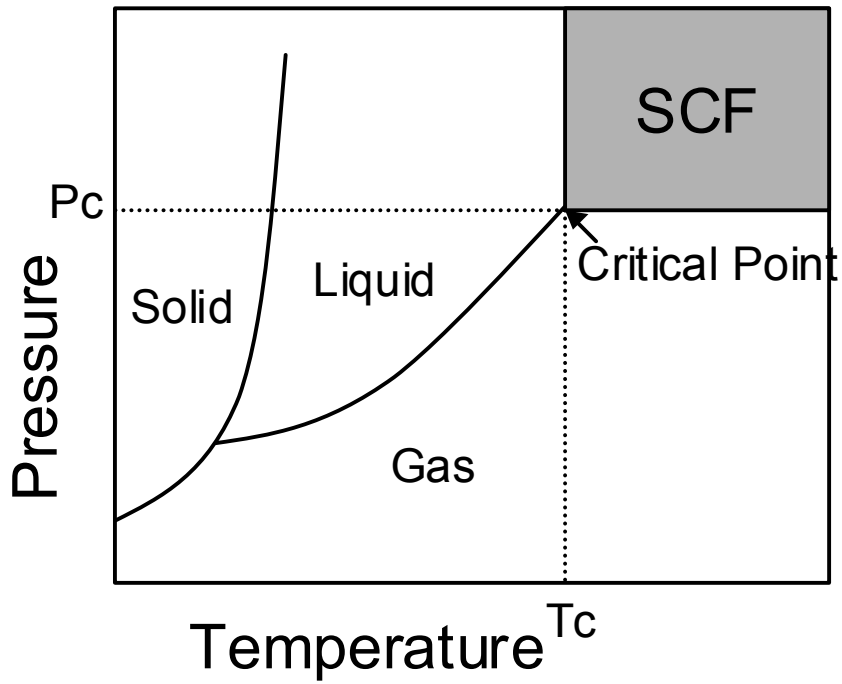
Supercritical carbon dioxide extraction is currently used in several food and pharmaceutical manufacturing applications. Its “greener” nature makes it a desirable option when compared with traditional organic solvent extractions. The purpose of this work is to compare the cost of using supercritical CO_2 to commercially extract peanut oil with that of the traditional hexane extraction process. Solubility values of peanut oil in supercritical CO_2 were also obtained under different conditions of temperature and pressure.

Supercritical Fluids

- Critical Temperature and Pressure
- Properties
  - Density of a liquid
  - Viscosity of a gas
  - Low surface tension
  - Adjustable density



Supercritical Fluids in Industry

- Reactions
  - SC Water Oxidation
  - Catalysis
- Pharmaceuticals
  - Particle Formulation
  - Drug Delivery
- Extraction
  - Petroleum
  - Coffee Decaffeination
  - Essential Oils

http://www.expsep.co.uk/

Carbon Dioxide Extraction

- Why CO_2?
  - "Greener" alternative to organic solvents
    - Non-toxic
    - Nonflammable
    - Relatively Inert
    - No detectable residue
  - Nonpolar solvent
  - Low critical conditions
    - Tc = 31.1ºC
    - Pc = 72.8 atm
  - Low cost

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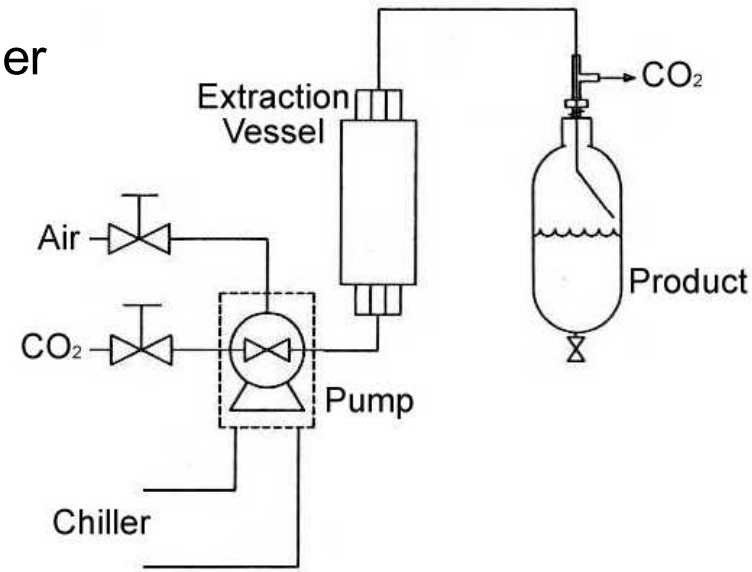
Experimental Apparatus

- Supercritical Fluid Technologies SFT-150
  - LED Temperature display/controller
    - Precision: ± 0.5ºC
  - Max Vessel Temperature: 300ºC
  - Max Operating Pressure: 680atm
  - Max Flowrate: 250g/min CO_2
  - Rupture disc safeguard
  - External Collection Vessel
  - Hand-tight vessel seals



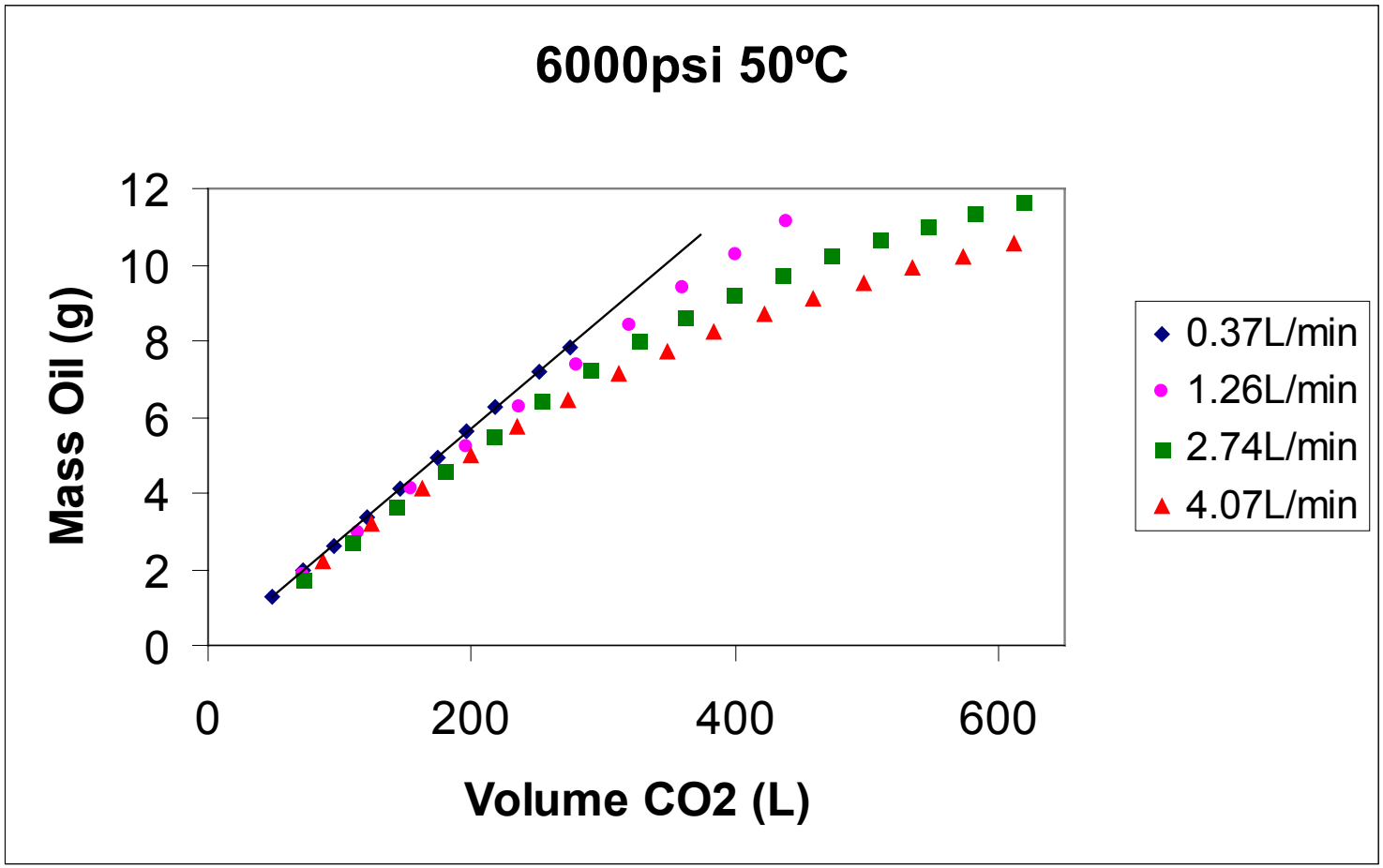
Materials

- Peanuts
  - Extra large, raw, unsalted
  - Supplied by Natural Health, Clementon, NJ
- Carbon Dioxide
  - Bone dry liquid with educator tube
  - 99.8% purity
  - Supplied by Messer Gas Technologies & Service Group

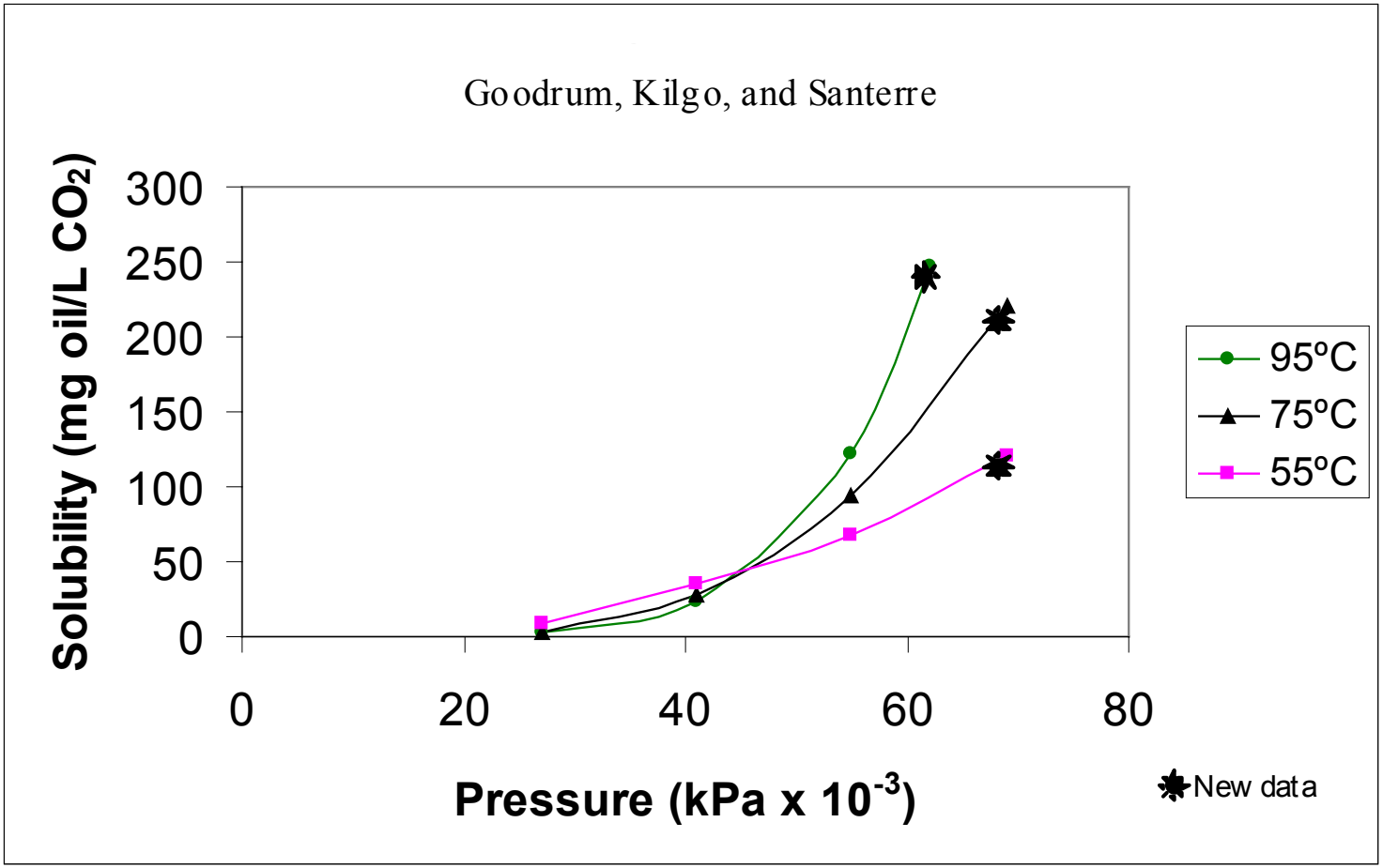
Procedure

- Setup
  - Sample chopped in food processor for 1min ± 0.1s
  - Loaded and packed into vessel
    - Glass wool used to prevent entrainment
  - Temperature and pressure set
  - CO_2 flow initiated
- Sampling
  - Sample weighed at volume increments
  - Gas volume recorded

Solubility Determination

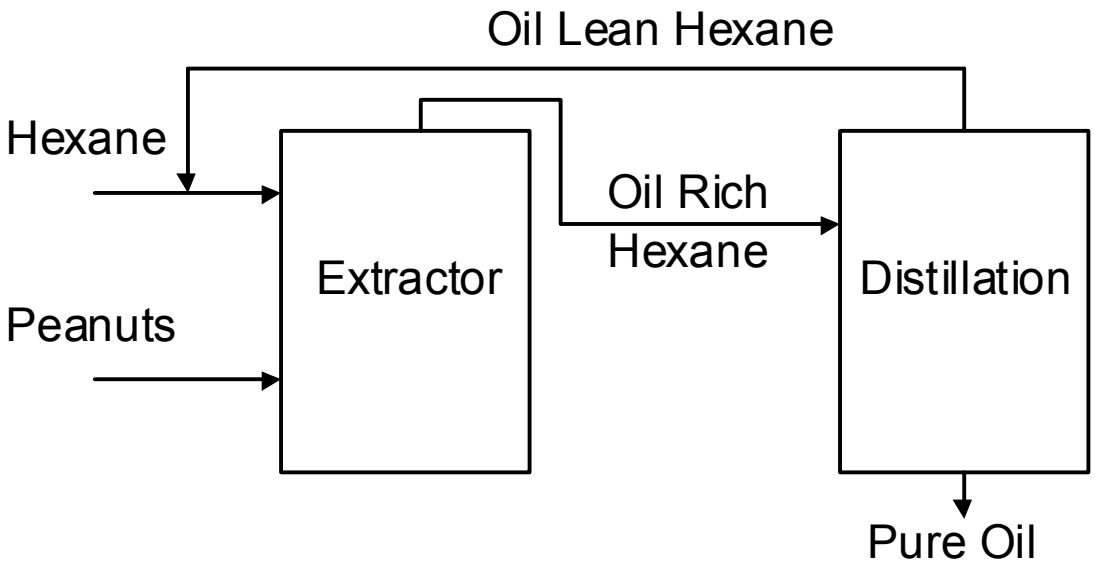


Peanut Oil Solubility



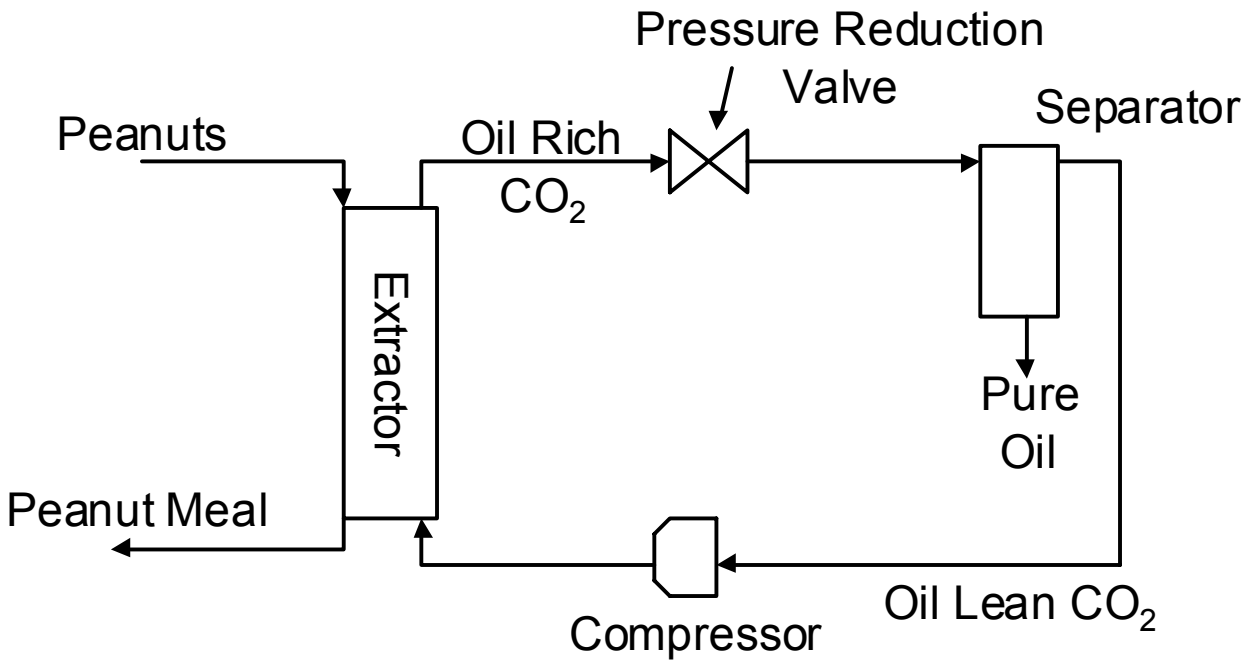
Hexane

- Major Process Costs
  - Materials (Peanuts, Hexane)
  - Distillation



Supercritical

- Major Process Costs
  - Materials (CO_2, Peanuts)
  - Compression



Results

- CO_2
  - 0.07$/lb
  - Max Solubility
    - 38 mg/g
  - CO_2 Flow
    - 87 million lb/yr
  - Energy input
    - 1.8 GWh/yr
  - Operating Cost
    - 6.2 million $/yr
- Hexane
  - 0.07$/lb
  - Max Solubility
    - 80mg/g
  - Hexane Flow
    - 38 million lb/yr
  - Energy input
    - 4.6 GWh/yr
  - Operating Cost
    - 14 million $/yr

Cost Comparison Hexane vs. CO_2

- Conditions
  - Peanut feed = 10 million lb/yr
  - Yeild = 30% (3 million lb/yr oil)
  - Supercritical extraction conditions
    - P = 550bar
    - T = 55°C
  - For separation, P = 270bar
- Use mass and energy balances with solubility data to determine the more energy efficient process

Conclusion

- SCFE Advantageous for Oil Extraction
  - Economical, uses half the energy of distillation
  - More environmentally friendly than hexane
  - Improved plant safety
  - One-step process

Future Plans

- Further Economic Studies
  - More detailed, broader analysis
  - Compare product qualities
- Improve Solubility Data
- Explore Other Oilseeds
- Develop Undergraduate Experiment