Mining Plants for Chemical and Pharmaceutical Feedstocks

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Starch, Cellulose, Hemicellulose

Sugars: glucose, fructose, xylose, arabinose, lactose, sucrose, starch

3 Carbon Feedstocks
- Glycerol
- Lactic Acid
- 3-hydroxypropionate
- Propionic Acid
- Malonic Acid
- Serine

Green solvents, Phthalate Polyesters, Polyacrylates, Polyacrylamides, Polyhydroxypolyesters, Amines, Antifreeze & De-icers, Emulsifiers, Resins & Crosslinkers, Reagent-building Units, Specialty Chemical Intermediates
Natural Latex (rubber)

- A biopolymer of isoprene units \((C_5H_8)_n\) linked together in a 1,4 \textit{cis}-configuration
- Considered a strategic resource used >40K items
- Often has superior performance characteristics compared to synthetic rubber
- Sources of high molecular weight latex:
  - Para rubber tree (\textit{Hevea brasiliensis})
  - Guayule (\textit{Parthenium argentatum})
  - Russian Dandelion (\textit{Taraxacum kok-saghyz})
Russian Dandelion, *Taraxacum kok-saghyz* (TKS),

- Russia obtained 30% of their rubber in the late 1930’s/early 1940’s from TKS (~67k ha)
- Was grown in NA as part of an emergency rubber project during WWII (~300 ha)
- Genetic improvement is needed to increase biomass and rubber production.
Russian Dandelion Project
(OMAFRA/University of Guelph)

• 3 year project to develop production practices for this crop (commencing this spring).
• Collaborating with Dr. Matt Kleinhenz at OSU who is currently identifying elite selections from the USDA’s TKS seed collection.
• TKS also produces significant amounts of inulin
• In addition, both chicory and Jerusalem artichoke are good sources.
• Inulin sugars, which are polymers of fructose with a terminal glucose, have great industrial potential.
Potential Industrial Uses of Inulin

- **Ethoxylated inulins**
  - improved the properties of water-blown polyurethane foams.
- **UV-photocrosslinked inulin derivatives**
  - produced hydrogels for drug delivery applications
- **Esterified inulins**
  - “Crystallization modifying agents” for TAG fractionation
- **Etherified inulins**
  - Carriers for water-insoluble substances (cosmetics/pharmaceuticals)
  - Emulsifiers in the textile and paper industries
- **Conversion into polylactides for use in the synthesis of bioplastics.**
Daffodils

- A local pharmaceutical company is studying several chemicals produced in daffodil bulbs.
  - Galanthamine is used for the treatment of Alzheimer’s disease
    - In 1998, 10000 ha of bulbs would have been needed to produce enough galanthamine for 30% of the population of Americans suffering Alzheimer’s
  - Compound “x” is being studied as a potential anti-cancer drug.
- The company currently buys their bulbs from Holland, but are interested in sourcing them domestically.
So…

• Can daffodil bulbs be economically grown as a source of pharmaceutical compounds
  – Variety trial underway to identify those with commercially viable concentrations of pharmaceutical compounds.
  – Do growing conditions affect secondary metabolite production?
Results to date

• Bulb yield does not increase over a single growing season (fall planting/summer harvest)

• Varieties differ in their concentrations of the chemicals we’re interested in
  – Galanthamine in freshly harvested bulbs
    • 0.0004 to 0.0786% (0.786g/kg), on a fresh weight basis
  – Galanthamine in stored bulbs
    • 0.0002 to 0.0554% on a fresh weight basis
Tobacco as an Industrial Crop

• Native tobacco protein has many uses:
  – Nutritional supplement
    • Contains all the essential amino acids humans need
    • Easily purified: tasteless, odourless
    • Useful for special needs patients
  – Processed food ingredient, additive in cosmetic and detergent formulations
    • Excellent foaming and emulsifying properties
Tobacco as an Industrial Crop

• Tobacco contains valuable compounds:
  – Solanesol
    • Used in the synthesis of co-enzyme Q9 (a cardiac drug), vitamin K (an anti-hemorrhagic vitamin) and vitamin E

  – Nicotine
    • production of smoking cessation products
    • Excellent insecticide
    • Nicotine drugs for treatment of ADHD, Parkinson’s and Alzheimer’s diseases?

1 www.chemicalbook.com, 2 www.itech.dickinson.edu
Production of High Value Proteins

• Genetically engineer tobacco to produce:
  – Pharmaceutical proteins, e.g. herceptin
  – Industrial proteins such as
    • recombinant antibodies for waste purification or protection against food borne pathogens.
    • Industrial enzymes e.g. cellulases, amylases and proteases
Tobacco as an Industrial Crop

- The key is to produce a lot of biomass by growing the tobacco at high density (247k/ha vs. 17.5k).
- High biomass yields are obtained through multiple harvests, the first done prior to the stretch bud stage.
Barriers to Economic Feasibility

• Markets
  – Access to existing & development of new markets
• Ability to maximize use of value added traits for economic gain
• Research
  – Production practices
  – Use of end products
• Food vs. non-food challenges
• Regulations and policy
Sponsors and Collaborators

The Ontario Ministry of Agriculture, Food and Rural Affairs

Agriculture and Agri-Food Canada

Agriculture et Agroalimentaire Canada

Canada Ontario Research Development Program

Ontario Research Development Program

The Ontario Flue-Cured Tobacco Grower’s Marketing Board