

Emerging Innovations and Logistics in Food Ingredient Processing



BIO-SCIENCES

NFP Consultation on Food Innovation Capacity
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POS Bio-Sciences Overview

- **POS is a fee-for-service contract research and development organization.**
- **Specialize in process development for extraction and purification of ingredients.**
- **Work with entrepreneurs to multi-national companies.**
- **A multi-scale processing facility for a wide range of bio-based materials.**
- **Extraction and isolation of components from plant and microbial sources.**



Concept to Commercialization

New process/product concept



Laboratory
(2 kg)



Mini-pilot scale trials
(20 kg)



Pilot scale development
(200 kg - Tonnes)



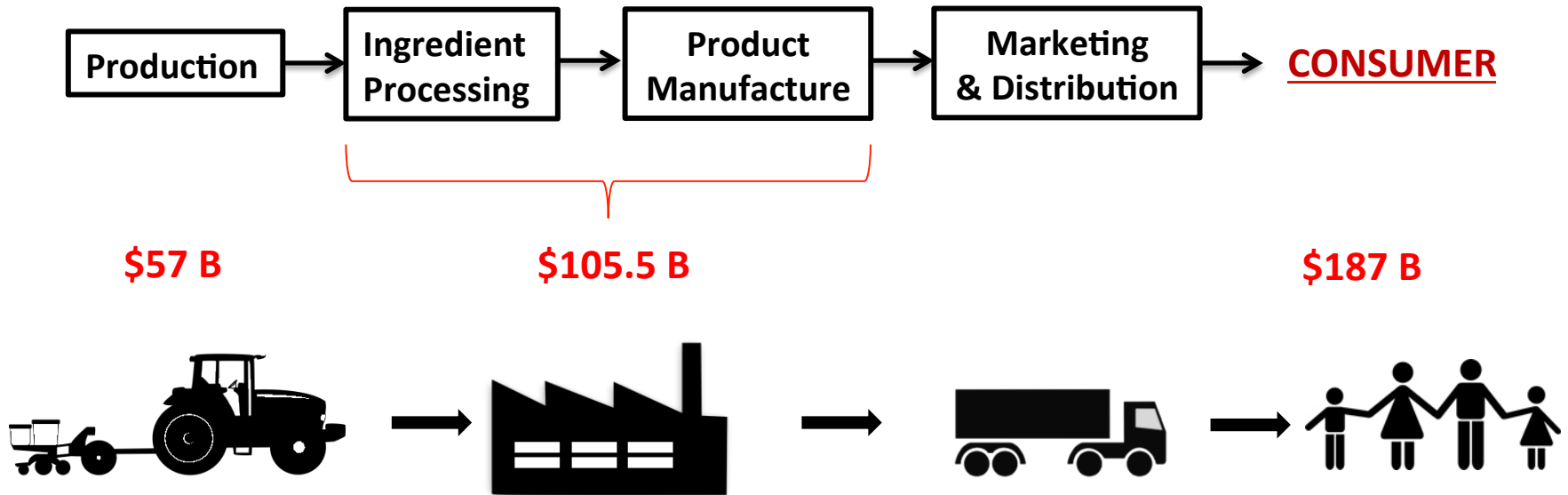
Custom/toll processing
(10 T - 1,000 T)



Commercial production



Agri-Food Value Chain in Canada (2015)



Food and beverage processing is the critical link in the “farm to fork” value chain that transforms agricultural products for consumers

Key Strategic Areas for Action

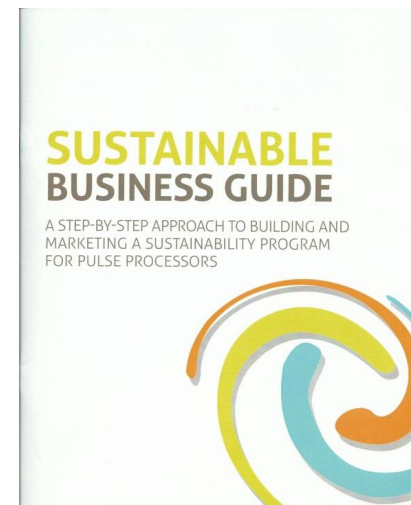
Food Processing Industry Roundtable identified a strategy to seize global growth opportunities by building a more productive, innovative and sustainable industry

1. Modernize plants/operations – i.e. technology
2. Increase innovation and differentiation
3. Improve collaboration with agriculture for more competitive ingredients
4. Grow global exports
5. Develop a globally competitive workforce
6. Build a more competitive, market-friendly environment



Key Trends/Drivers: Opportunities for Value-added Ingredients

- **Natural ingredients (replace synthetics)**
- **Clean labels**
- **Sustainable production of ingredients, foods**
- **Organic foods**
- **Healthy foods**
 - **low fat**
 - **no-trans**
 - **Omega-3**
 - **low sodium**
 - **high fibre**



Key Trends/Drivers: Opportunities for Value-added Ingredients

- Designer oils
- Bioactive (phytochemicals) extracts
- Beta-glucan, phytosterols, nutritional lipids, probiotics, prebiotics
- Alternative sources of protein
 - e.g. Hemp, quinoa, pulses
 - unique functionality
 - gluten-free
 - non-allergenic
 - alternatives to animal protein



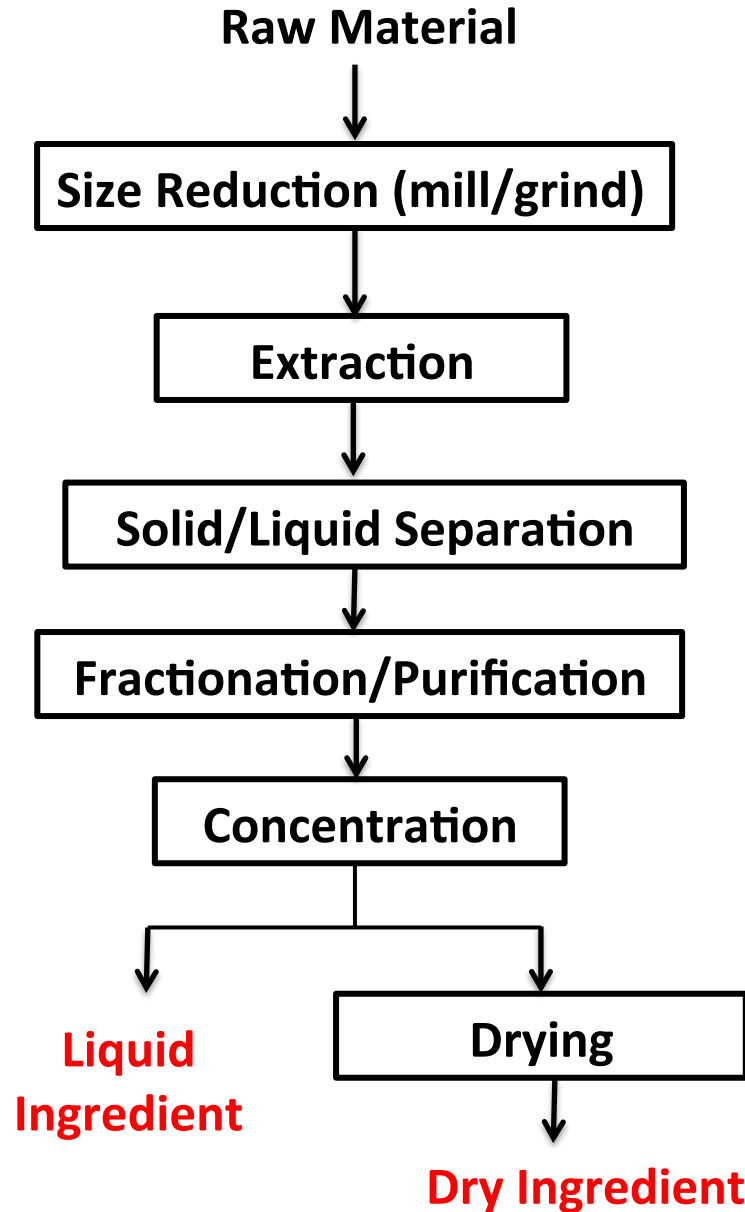
These trends also apply to feeds.



Technologies for Innovative Ingredients

- Application of effective processing technologies enables production of high quality, competitive food ingredients.
- Technologies
 - New applications of existing technologies
 - Incremental advances in existing (Technology Advancement)
 - New, disruptive technology (Emerging Technology)
 - Longer development time, may be higher risk however higher reward.

Overview of Ingredient Processing



Raw Material Input for Food Production in MB

- Pulses
- Cereals
- Oilseeds
- Fruit, Vegetables
- Botanicals
- Red Meat
- Poultry and Eggs
- Dairy
- Freshwater Fish

**Focus on these
raw materials**



Some Value-Added Ingredient Opportunities: Pulses & Cereals

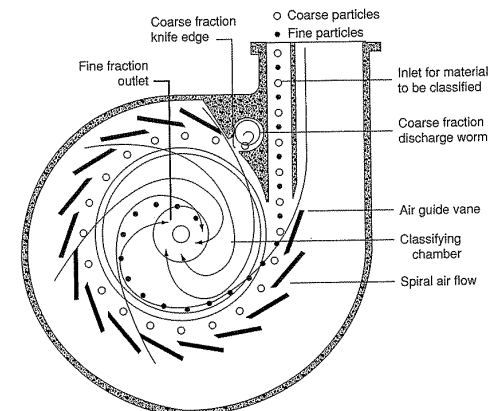
- **Fibre/bran for functional food and natural health product markets**
- **New protein sources – Pea protein**
 - Non-allergenic, bland taste, functionality for food formulations
- **Antioxidants from hulls**
- **Pre-biotics**
- **Modified starches for food and industrial uses**
- **Seed/germ oil**



Technology Advancement

Dry Milling/Dry Fractionation of Pulses and Cereals

- For production of specialty flours
- Advances in milling and air classification equipment – allows for production of higher purity protein fractions.
- Protein concentration of 45 to 60%
- Lower cost than wet processing



Pin Mill



Air Classifier

Wet Extraction of Proteins/Peptides



Meal, Flour

Water

Alkali Extraction

Centrifugation

Water

Starchy Solids

Starch, Fibre

Protein Solution

Fractionation

Acidify

Water

Centrifugation

Water

Protein Solids

Washing & Centrifugation

Spray Dry

Protein Isolate (>80% protein)

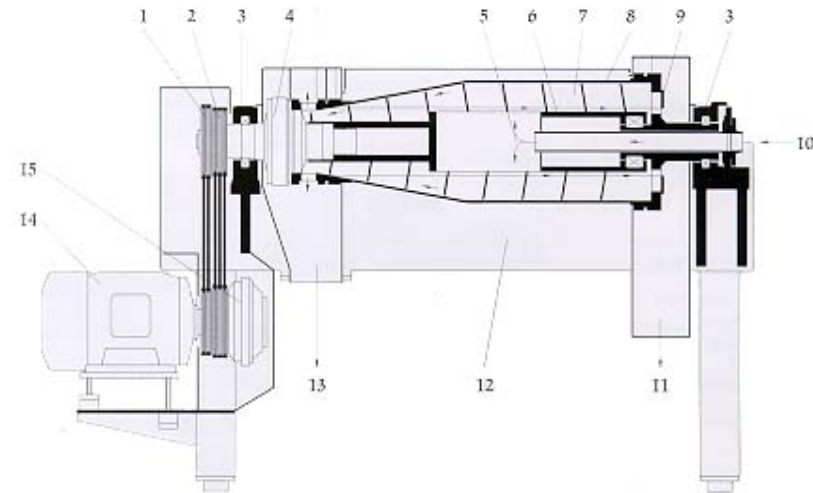


Process to bioactive peptides

Technology Advancement

3-phase coarse solids separation in protein extraction

- Three phase decanter (e.g. Tricanter) centrifuges for more effective/efficient separation of starch, fibre and protein streams.



Decanter Centrifuge

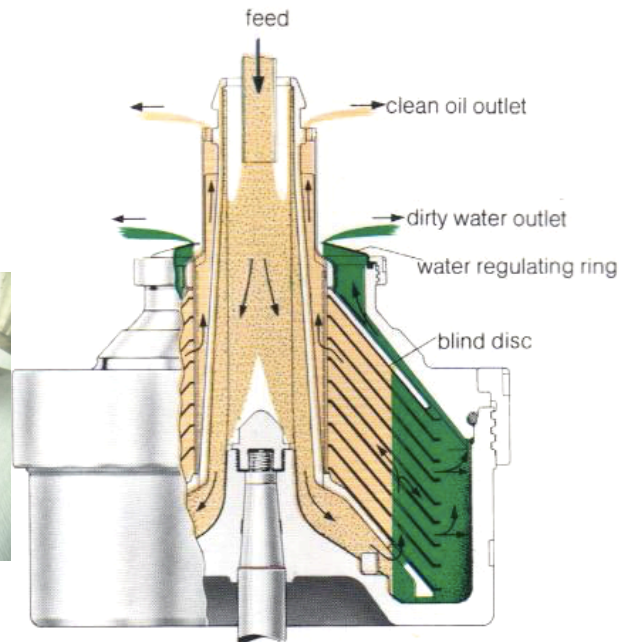
Technology Advancement

Higher g -force disc centrifuges

- Higher g -force (up to 12,000 $\times g$) for more effective separation
 - Separation of fine solids from protein solution
- Lower cost, higher purity, higher yield protein
- An increase of yield by 2% \times 2 centrifugation steps, > 4% increase in product yield

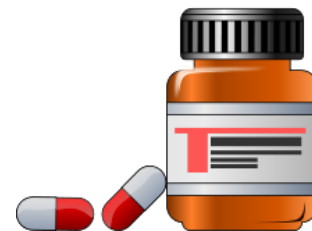


**Continuous Clarifier
Centrifuge**



Why Fractionate Proteins?

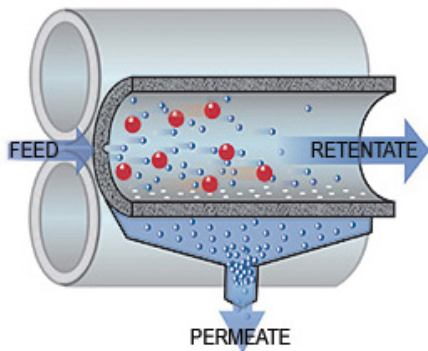
- Higher nutritional value
- Soluble for beverages
- Insoluble textured protein
- Better emulsification
- Flavour
- Viscosity
- Gelation properties
- More desirable texture
- Heat stability
- Aeration
- Foaming properties
- Health benefits
 - Reduce risk of disease
 - Mediate symptoms



Technology Advancement

More efficient membrane filtration systems

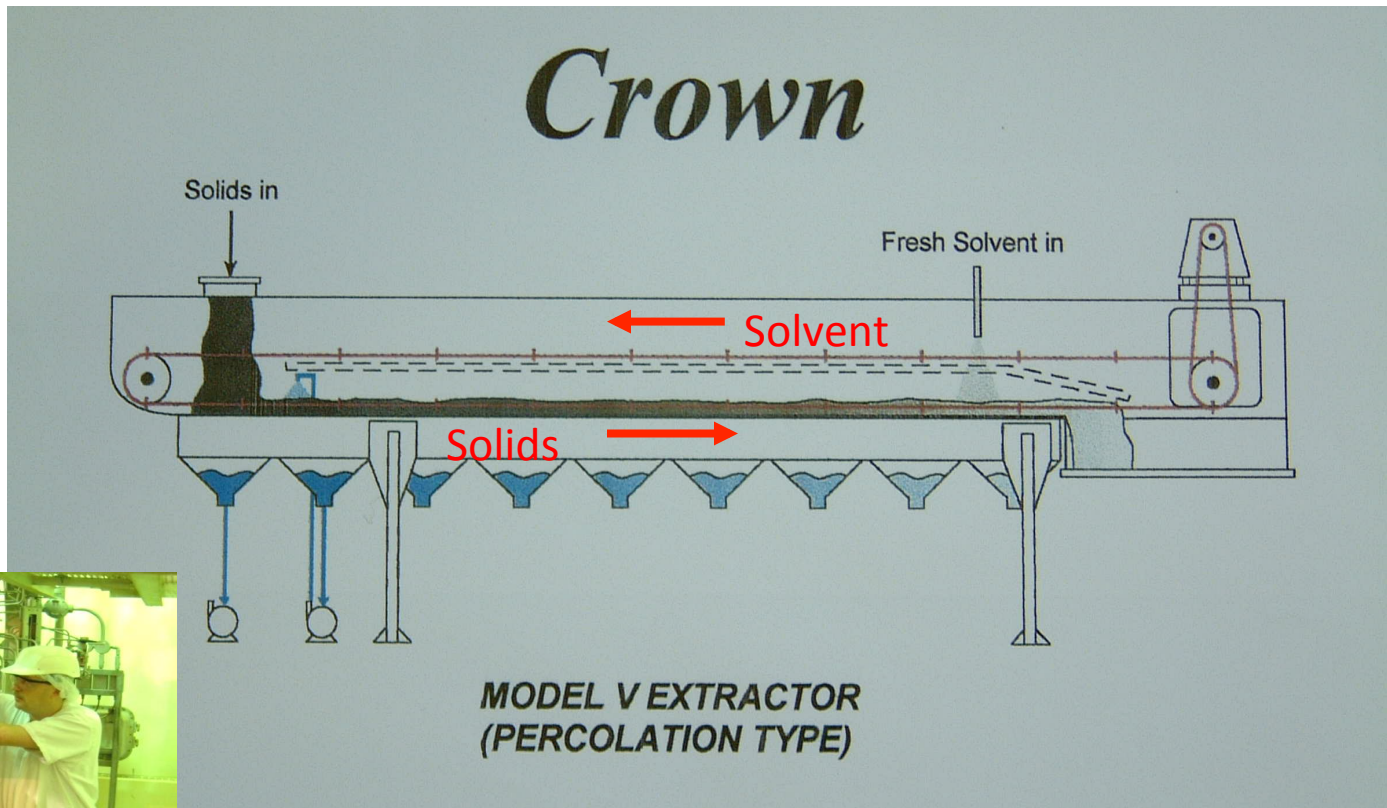
- Separation of compounds in solution based on their molecular size 200 - 100,000 MW. (nanofiltration, ultra-filtration, micro-filtration).
- Various commercial proteins and carbohydrate-based ingredients as well as phytochemicals are fractionated (purified) by membrane filtration.
- Also for isolation of nanoparticles.



Emerging Technology

Counter-current extraction for plant protein, fibre, starch

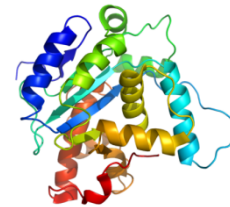
- Continuous extraction is more efficient than batch extraction.
- Equipment design/adaptation for extraction of new feedstocks is needed.



Technology Advancement

Enzyme-assisted, chemical-free processing

- More efficient enzymes
 - for extraction, purification, modification of ingredients
- Reduced water usage
- Production of clean-label ingredients



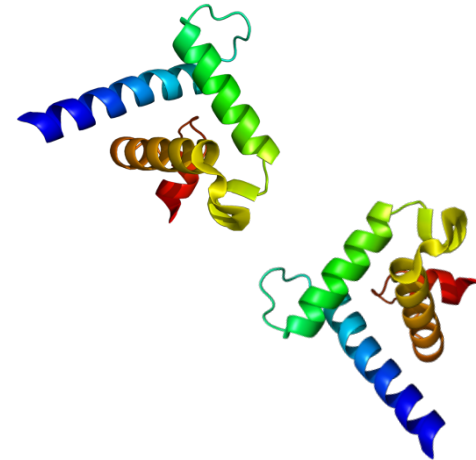
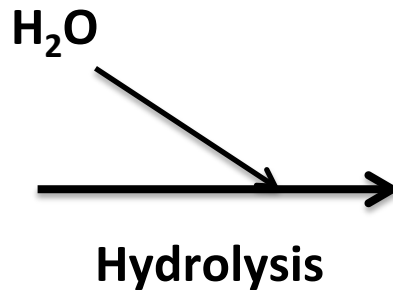
Emerging Technology

Bioactive Peptides

- Chemical hydrolysis
- Enzyme hydrolysis



Protein



Peptides

- Physiological benefits – functional food ingredients
- Increased solubility
- Biopesticide activity, etc.

Technology Advancement

Waste water recycling systems for processing plants

- More effective water management is needed throughout the food manufacturing industry.
- Particularly large water usage for plant protein, starch and fibre processing.



Emerging Technology

New product development using value-added, innovative ingredients

- Extruded meat analogues from plant proteins and starches
- New food product formulations using new ingredients
- Support for new ingredients
- Nutritional and clinical studies



Some Value-Added Ingredient Opportunities: Oilseeds

Meal

- New feed formulations
- Aquaculture feeds
- Protein
- Antioxidants from hulls
- Emulsifiers
- Mucilage-based thickeners for food and industrial uses



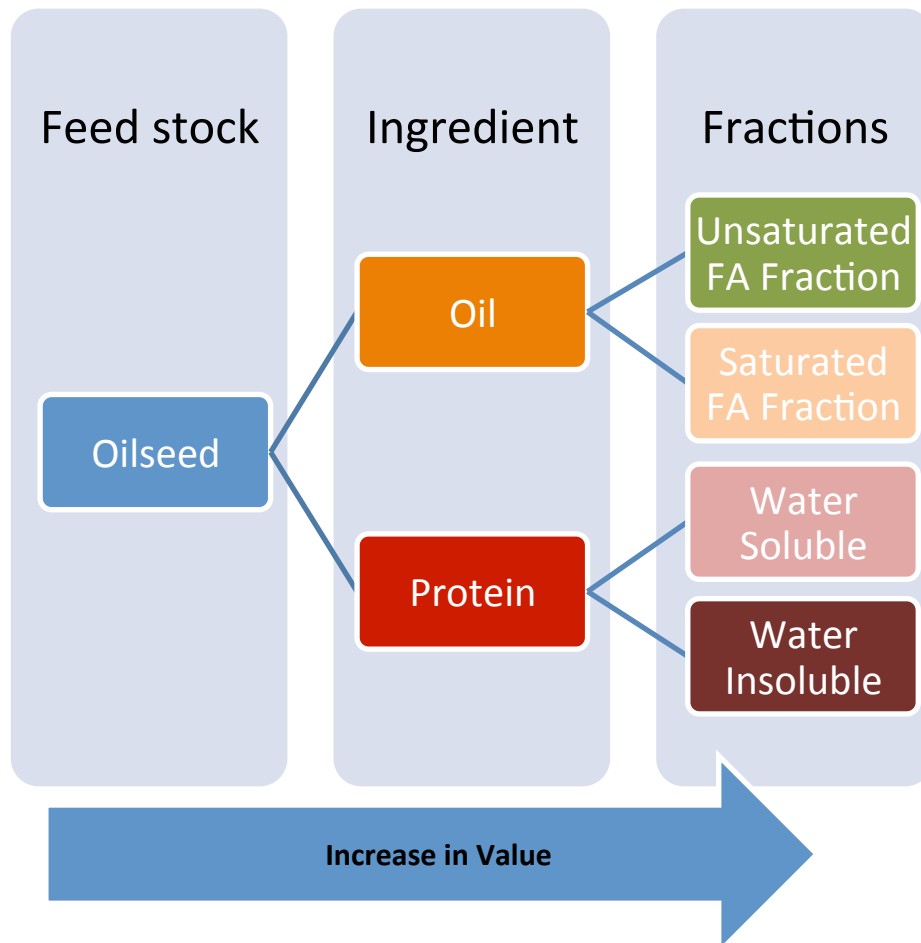
Some Value-Added Ingredient Opportunities: Oilseeds

Oil

- Nutritional lipids
- Lipid fractions
- No-trans fat
- Omega-3 fats
- Greater stability – e.g. for frying
- Industrial oils
- Biodiesel, biofuel
- Designer oils



Fractionation – Higher Value Ingredients



Short Path Distillation

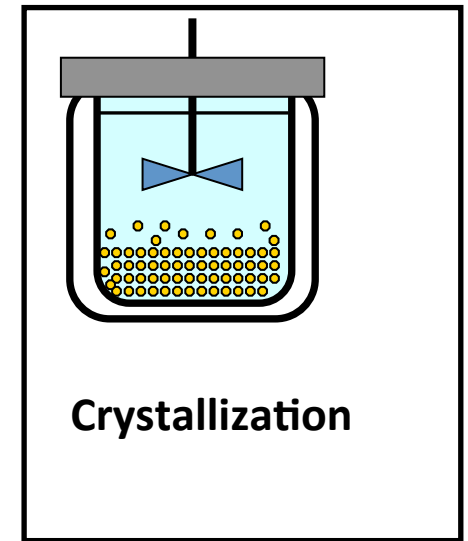


Ultrafiltration

Technology Advancement

Fractionation and formulation of oils

Collaboration opportunities



Short path distillation
(POS is well equipped)

- Fractionation of oils, waxes, essential oils
- Preparation of value-added fractions
(e.g. PUFA rich concentrates, saturates for no-trans formulations)

Emerging Technology

Oil stabilization ingredients, formulations, technologies

- Natural antioxidants from plant extracts
- Emulsions, microemulsions, nanoemulsions
- High pressure homogenizers
 - application for producing stable oil-water formulations/emulsions
 - can produce clear nanoemulsions (“water soluble lipids”)
 - pressures up to 25,000 psi
 - also used for processing of microencapsulated ingredients



Emerging Technology

Microencapsulation: processing and formulations

Microencapsulated ingredients

- Oils: polyunsaturated enriched oils
- Flavours & Aromas
- Nutraceuticals
- Well known technology but room for much improvement

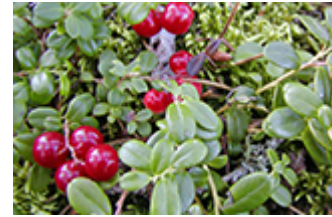
Benefits of Microencapsulation

- Increase stability
- Easier to formulate
- Convert to powdered form for easier handling
- Masking of off-flavour

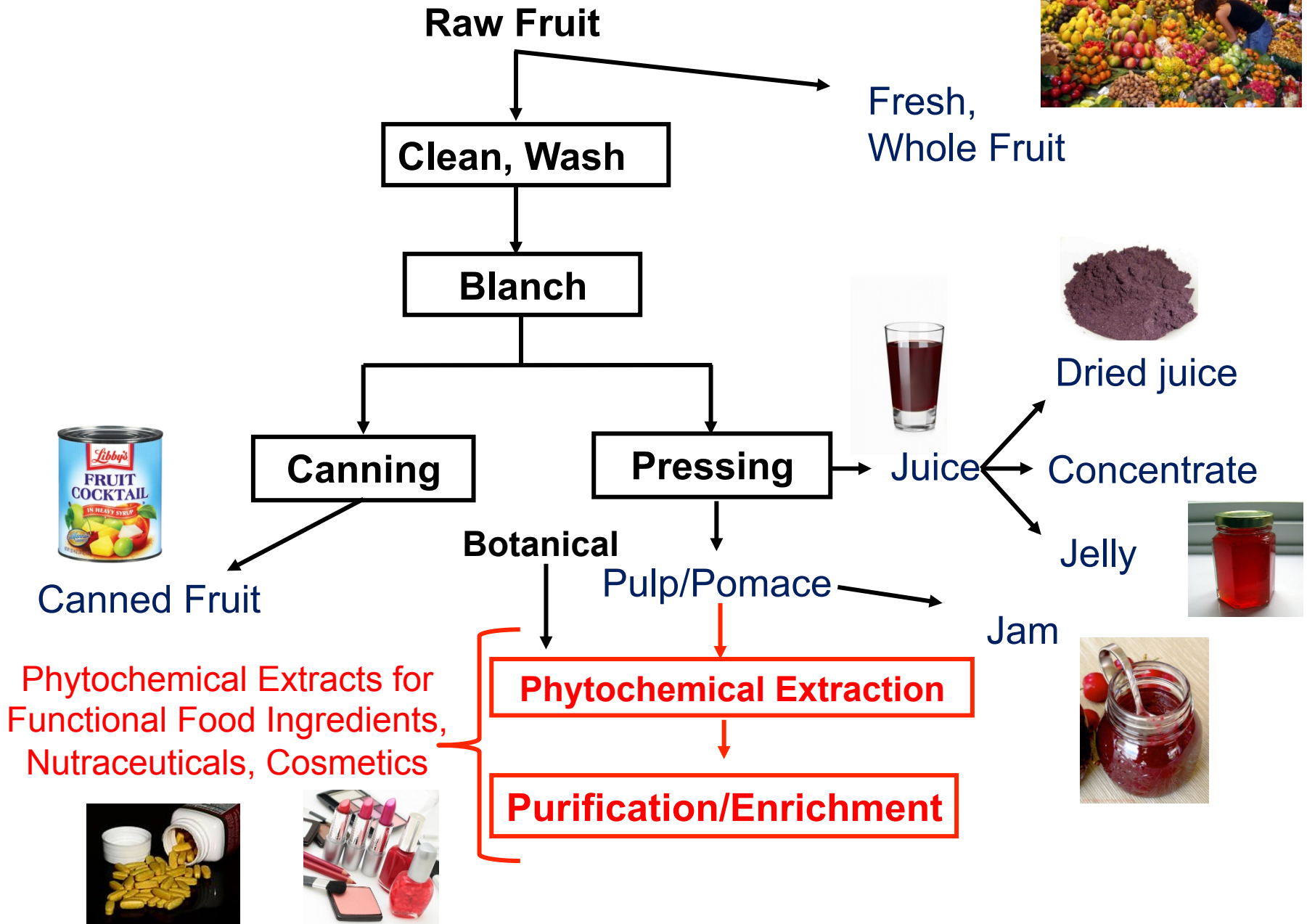


Some Value-Added Ingredient Opportunities – Fruits/Horticulture

- Juices, concentrates, powdered juice
- Unique seed oils for cosmetic and food use
- Bioactive extracts
- Natural pigments for foods & beverages
- Flavours for foods & beverages
- Natural source of vitamins and minerals
- Fibre for functional food and NHP markets



Fruit Co-products



Modified and Emerging Extraction Techniques for Phytochemicals

- Solvent Extraction (ethanol, acetone, hexane, etc.)
- Aqueous, Non-solvent
- Enzyme Assisted Aqueous
- Supercritical Fluids
- Subcritical Water/Pressurized Low Polarity Water
- Microwave Assisted Organic Solvent

Options to increase economic viability!



Emerging Technology

Aqueous and Enzyme-assisted Aqueous Extraction

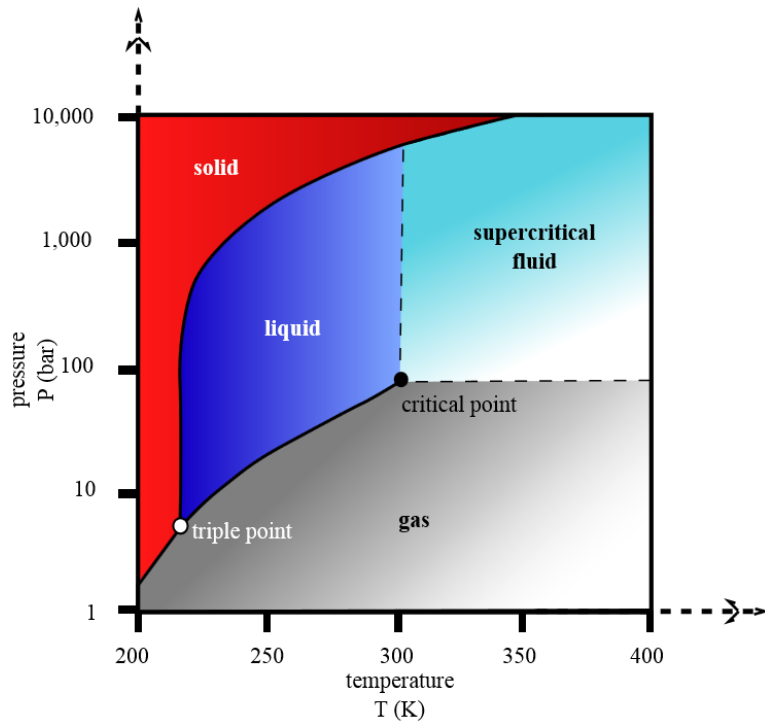
- **Hot water extraction**
- **Mechanical agitation to increase extractability**
- **Enzymes may be used to degrade cell walls or contaminants (significant advances in and new enzyme-assisted extraction techniques are emerging)**



Technology Advancement

Supercritical carbon dioxide extraction

- Classed as a non-solvent extraction
- Can use ethanol co-solvent
- Batch extraction technique, high pressure
- Extraction of non-polars and slightly polars



Emerging Technology

Pressurized Low Polarity Water Extraction

- **Aqueous extraction**
- **Polar & some non-polar bioactives**
- **Temperatures of 100 - 350°C, ~ 16 to 230 bar**
- **Very effective for phenolic compounds**
- **At high pressure, water becomes non-polar**



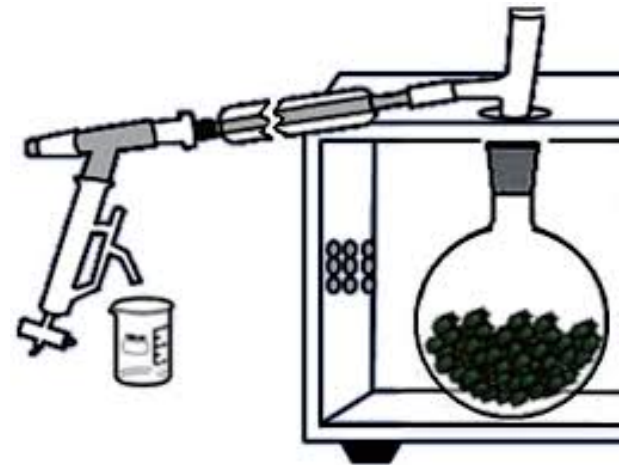
Emerging Technology

Microwave Assisted Solvent Extraction

- Microwaves selectively heat the moisture in plant material – damages cell wall to release bioactive compounds
- Organic solvent is not heated by microwaves
- Reduced extraction time, higher yield
- Low temperature extraction, low solvent use



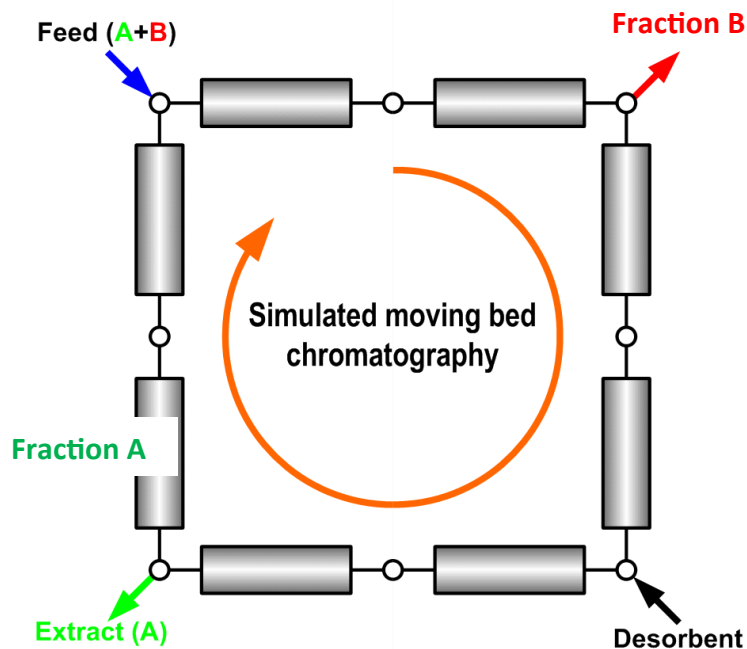
www.researchgate.net



www.jmpee.org

Emerging Technology

Purification of Phytochemicals by Simulated Moving Bed Chromatography



- Lower cost than column chrom.
- Continuous chromatography system
- Large scale is available

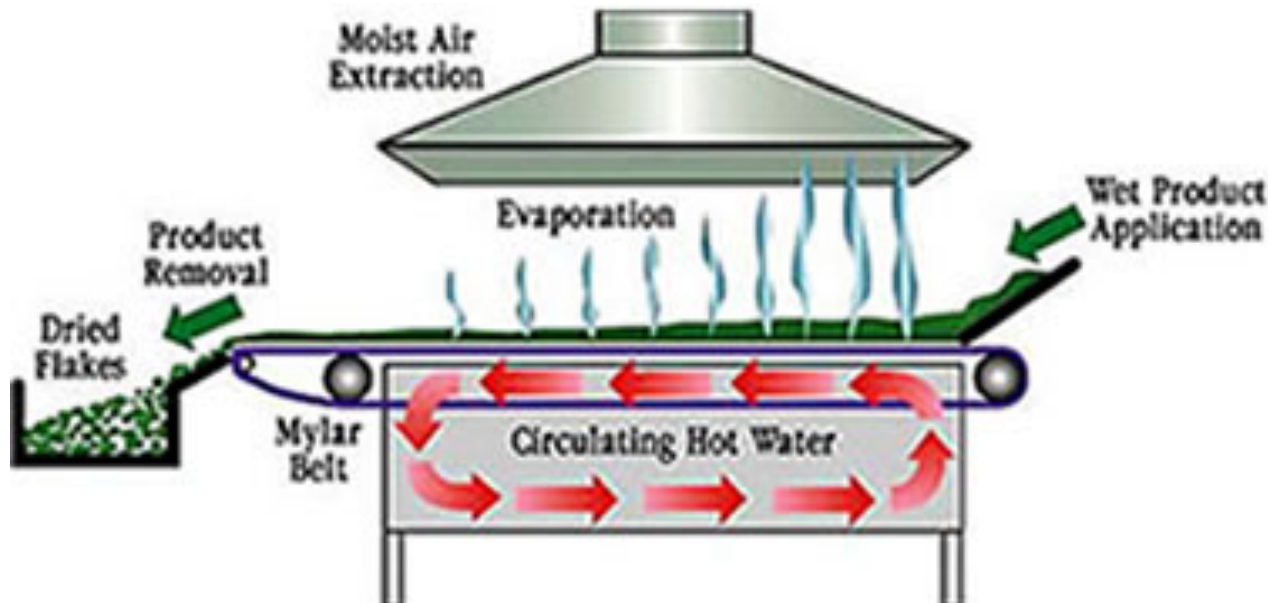
www.mpi-magdeburg.mpg.de
novasep.com



Emerging Technology

Refractance Window Drying

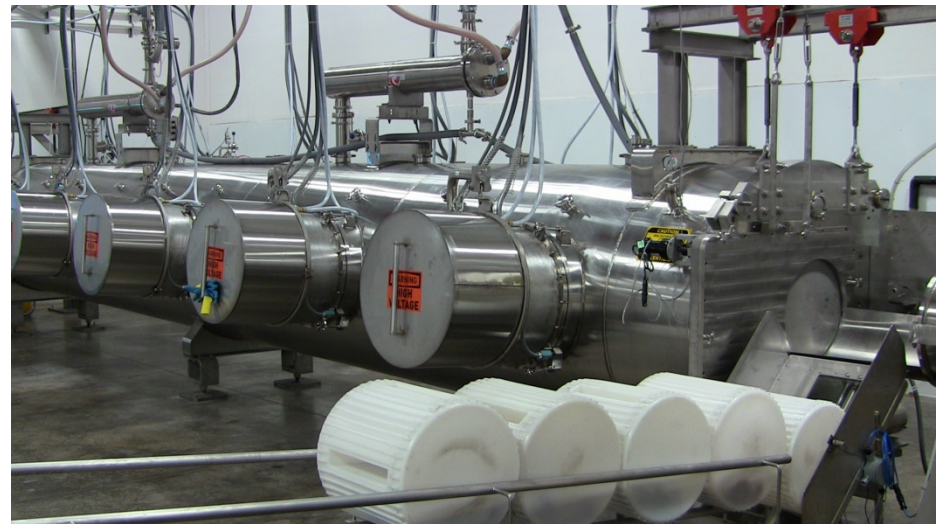
- Low temperature, continuous dryer
- Minimal damage to heat labile compounds such as phytochemicals
- Evaporation and belt drying system
 - A window for infrared radiation
 - Effective for fruits and vegetables



Emerging Technology

Microwave Vacuum Drying

- Low temperature, continuous dryer
- Minimal damage to heat labile compounds such as phytochemicals



Enwave microwave vacuum dryers

Other Emerging Technologies

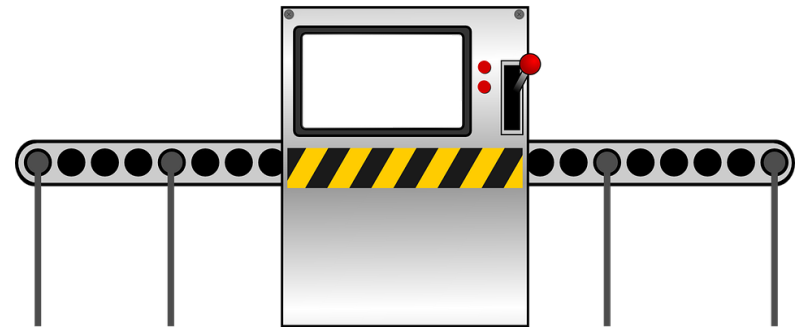
Fermentation

- For fermented foods and beverages
- Microbes for value-added ingredients
 - Microalgae
 - Yeast
 - Food-grade bacteria



Other Emerging Technologies

- **Non-thermal processing**
 - High pressure pasteurization
 - Ohmic heating
 - Pulsed electric fields
 - Infrared processing
- **Process line efficiency systems**
 - Robotics
 - Automation for process line control and sample analysis



Business Strategies for Logistics for New Innovation

- **Integrated supply chain (vertical integration)**
- **Multi-functional team for new ingredient development**
- **Process development**
- **Product development/prototypes**
- **First to market – short development time**
- **Quality-by-design approach**
- **Techno-economic analysis early in the development cycle**
- **Advantages gained through COLLABORATION**



Summary

Technology Advancements

- **Milling and dry fractionation of protein enriched flours**
- **More efficient and effective centrifuges for separation – increase purity and yield**
- **Membrane technology for fractionation/purification**
- **Enzyme assisted extraction and processing**
- **Water recycling**
- **Oil fractionation – short path distillation and crystallization**
- **Supercritical fluid extraction**

Summary

Emerging Technologies

- **New counter-current extraction equipment/applications**
- **Processes for bioactive peptide production**
- **Product development using new ingredients**
- **Natural antioxidants for food and oils stabilization**
- **Stabilized emulsions using high pressure homogenization**
- **Microencapsulation**
- **Aqueous extraction**
- **Pressurized low polarity water extraction**
- **Microwave assisted extraction**

Summary

Emerging Technologies

- Purification by simulated moving bed chromatography
- Refractance window drying
- Microwave vacuum drying
- Fermentation of value-added ingredients/organisms producing such ingredients
- Non-thermal processing
- Robotics and automation

A collaborative, multi-functional team approach is necessary for the successful development of innovative food ingredients.

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Thank You!