Non-Conventional Approach/Technologies For Value-Add to Agriculture & Food Industry

(Secondary Agriculture Technologies)

Foodworld India

November 2011

Arvind Lali

DBT-ICT Centre for Energy Biosciences

Institute of Chemical Technology (formerly UDCT)

Matunga, Mumbai, INDIA

Agriculture

India GDP = 1.8 trillion USD
Agriculture = 350 billion USD (18% approx → provides 60% jobs)

Cereals + Rice + Wheat	= 400 million ton/year
Sugar cane	= 300 million ton/year
Oil seeds	= 25 million ton/year

Agriculture Industry

Post-harvest activities including processing and preserving of agricultural products for the purpose of midway or final consumption.

Agricultural products + services = 1100 billion USD (~60% of GDP)

Current Needs

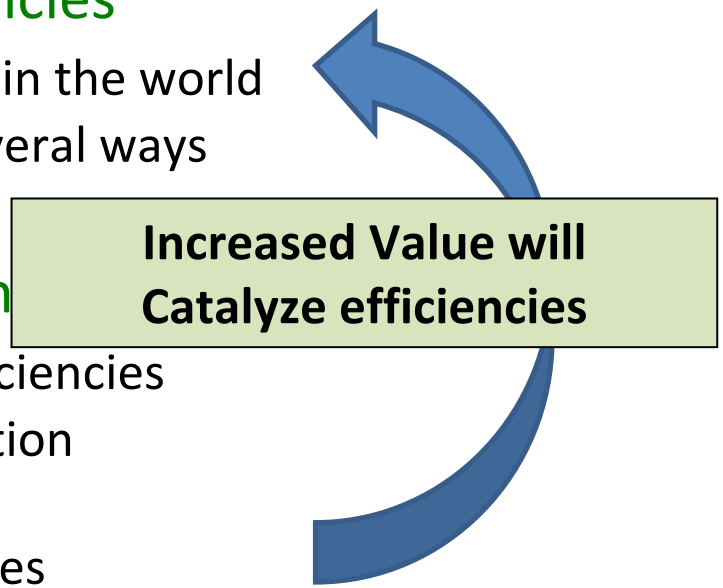
- To increase farming efficiencies
  - Far lower than the best in the world
  - Several reasons and Several ways

- To modernize agriculture industry
  - Increase processing efficiencies
  - Decrease waste generation
  - Devise new products
  - Devise novel technologies
    - *Indigenous technologies*
    - *Effective deployment*

Current Needs

- To increase farming efficiencies
  - Far lower than the best in the world
  - Several reasons and Several ways

- To modernize agriculture in
  - Increase processing efficiencies
  - Decrease waste generation
  - Devise new products
  - Devise novel technologies
    - *Indigenous technologies*
    - *Effective deployment*



Current Needs

- To increase farming efficiencies
  - Far lower than the best in the world
  - Several reasons and Several ways

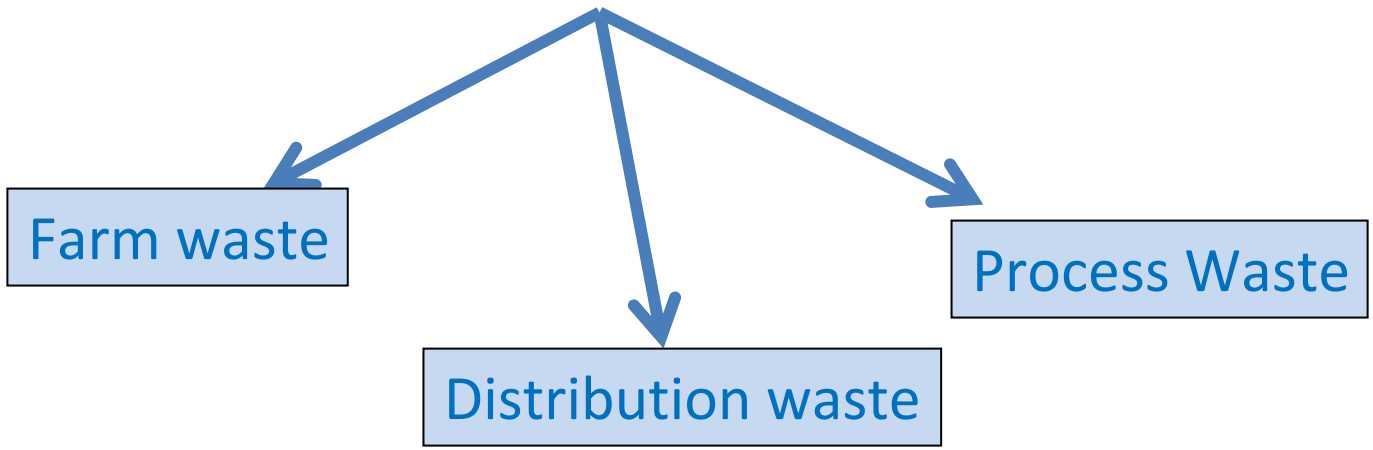
- To modernize agriculture industry
  - Increase processing efficiencies
  - Decrease waste generation
  - Devise new products
  - **Devise novel technologies**
    - ***Indigenous technologies***
    - ***Effective deployment***

Required → Transformation of Indian Agriculture Industry

- Better products + Better productivity
- New Products
- Decrease waste
- **Add value to waste**

Transformation of Indian Agriculture Industry

- Better products and Better productivity
- New Products
- Decrease waste
- **Add value to waste**



Farm Waste : Surplus Biomass

Non-food & Non-fodder Biomass

- *Cotton Stalk*
- *Wheat Straw*
- *Rice Straw*
- *Sugar Cane trash*
- *Many others*

Annual availability > 400 million ton

(total grain production = 400 million ton)

Crop residues	Production Million tons	
	1994	**2010 (projected)**
Field based residues		
Cotton stalk	19.39	30.79
Rice straw	214.35	284.99
Wheat straw	103.48	159
Maize Stalk	18.98	29.07
Soybeans	12.87	34.87
Jute stalk	4.58	1.21
Sugarcane tops	68.12	117.97
Ground nut straw	19	23.16
Processing Based residue		
Rice Husk	32.57	43.31
Rice Bran	10.13	13.46
Maize cob	2.59	3.97
Maize Husk	1.90	2.91
Coconut shell	0.94	1.50
Coconut husks	3.27	5.22
Ground Nut Husk	3.94	4.80
Sugarcane bagasse	**65**	**114.04**
Coffee husk	0.36	0.28

SUGARCANE RESIDUE

Sugarcane : A crop grown extensively

Cultivation area : 4 million ha
Cane produced : 300 million tons/year

Farm waste:
Sugarcane trash : 40 million tons/year

Process waste:
Bagasse available : 30 million tons/year

Vegetable & Fruit Waste

Annual Vegetable + Fruit Production = 150 million ton/year
Handling + Processing Waste = 50 million ton (~30% !!)

Oil Industry Waste

Oil Seed Production = 35 million tons/year

Process Waste

Oil cake production = 7 million ton/year (@20% of seed)
Other waste components (examples):

Groundnut/Coconut etc shells
Empty Fruit Bunch (palm)

Known Waste-to-wealth Technologies:

- Animal feed
- Burning for primary energy (co-generation)
- Conversion to Biogas
- Composting to bio-fertilizer
- Conversion to fermentation products
  - *proteins, alcohol etc.*

Low value technologies

Need to shift to High Level Technologies

High Level Technologies

High Volume - Low Value Products

- Conversion to biofuels/biochemicals
- Conversion to bulk food products (e.g. sugar, vinegar)

High Value - Low Volume Products

- Isolation of Nutraceuticals
- Conversion to High Value Food/Pharma products

High Level Technologies

High Volume - Low Value Products

- Conversion to biofuels/biochemicals

- Conversion to bulk food products (e.g. sugar, vinegar)

Biomass to Ethanol, Butanol, Acetic Acid, Acetone, Furfural etc.

High Value - Low Volume Products

- Isolation of Nutraceuticals
- Conversion to High Value Food/Pharma products

High Level Technologies

High Volume - Low Value Products

- Conversion to biofuels/biochemicals
- **Conversion to bulk food products (e.g. sugar, vinegar)**

High Value

Biomass to Sugar, Xylitol, Gluconic Acid, Vinegar, etc.

- Isolation of Nutraceuticals
- Conversion to High Value Food/Pharma products

High Level Technologies

High Volume - Low Value Products

- Conversion to biofuels/biochemicals
- Conversion to bulk food products (e.g. sugar, vinegar)

High Value - Low Volume Products

- Isolation of Nutraceuticals

Recover of Carotenes and Tocopherols from Vegetable Oils
Recovery of Protein and Isoflavones from oil seed meals

High Level Technologies

High Volume - Low Value Products

- Conversion to biofuels/biochemicals
- Conversion to bulk food products (e.g. sugar, vinegar)

High Value - Low Volume Products

Bio/Chemical Conversion to Structured Lipids and Fats, Natural Flavors, Pharma intermediates

- Conversion to High Value Food/Pharma products

Current Status of Value-Addition Approaches

- Inadequately developed Sub-optimal technologies
- Most attempts → Single Product Technologies
- Process Waste Generating Technologies

Result → High CAPEX - Low Return
→ High Risk → Low Sustainability

The BioRefinery Concept

The concept of BIOREFINERY

"A Biorefinery is

- a zero-waste producing collection of processes that
- utilizes renewable biological or bio-based sources
- to produce several products, whereby
- each component of the renewable biological or bio-based sources, is converted or utilized in a manner to add value, and hence sustainability to the processing plant."

Potential Biorefineries :

Sugar Mills
Vegetable oil Mills
Grain processing Mills
Milk Dairy
BioFuel plant

Development of
BioFuel and BioRefinery Technologies
at

DBT-ICT Centre for Energy Biosciences

Institute of Chemical Technology (UDCT)

Matunga, Mumbai

INDIA

The Facility at the Centre
A State-of-the-Art Facility for

- Molecular Engineering at the interface of Biology, Chemistry and Engineering
- Synthetic Biology
- Recombinant DNA technology
- Microbial Proteomics
- Metabolomics and Metabolic Engineering
- Fermentation Technology
- Enzyme Technology
- Separation Technologies
- Bioinformatics and Molecular modeling

The Facility at the Centre
A State-of-the-Art Facility for

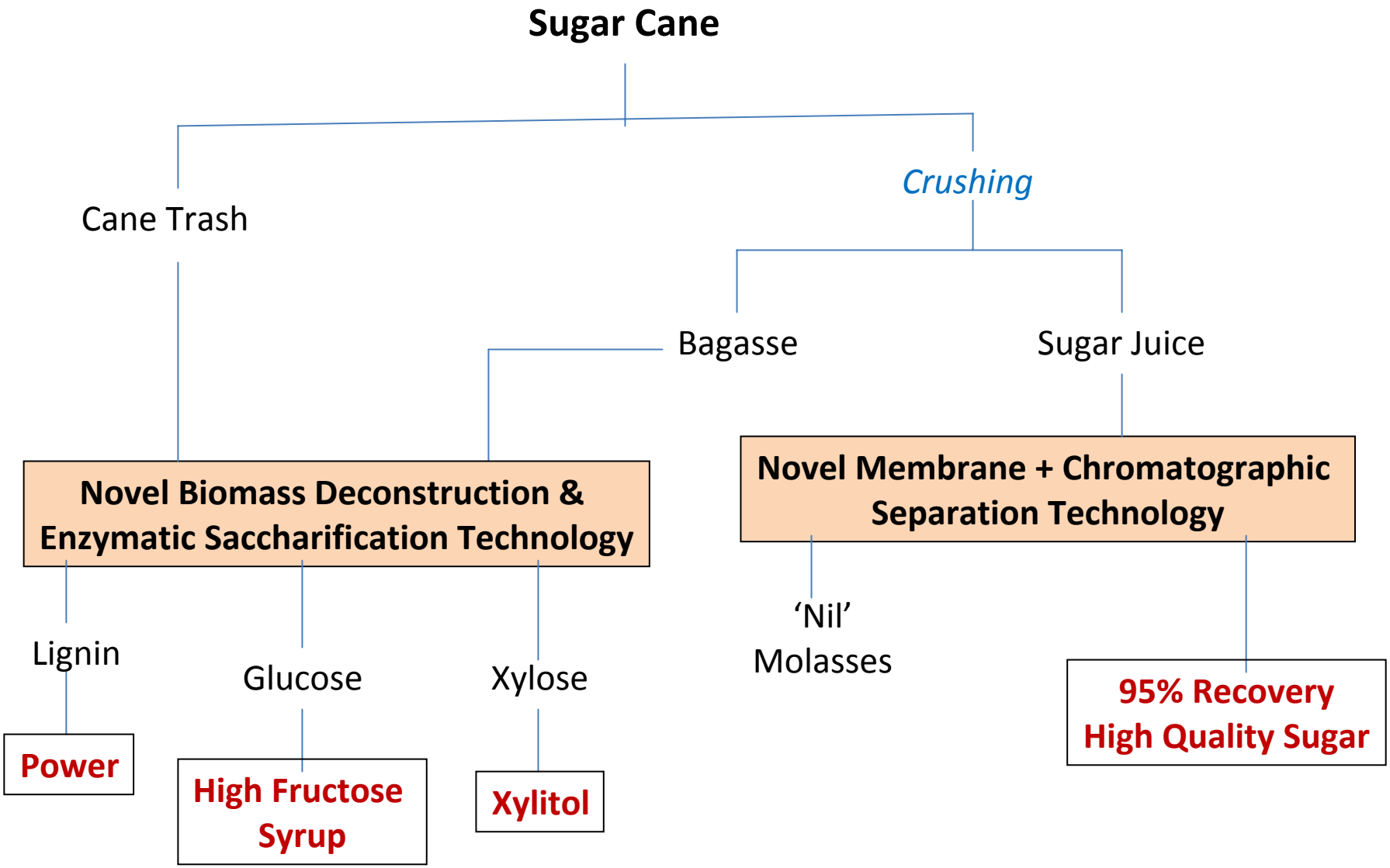
- Molecular Engineering at the interface of Biology, Chemistry and Engineering

Modern Separation and BioTransformation Technologies

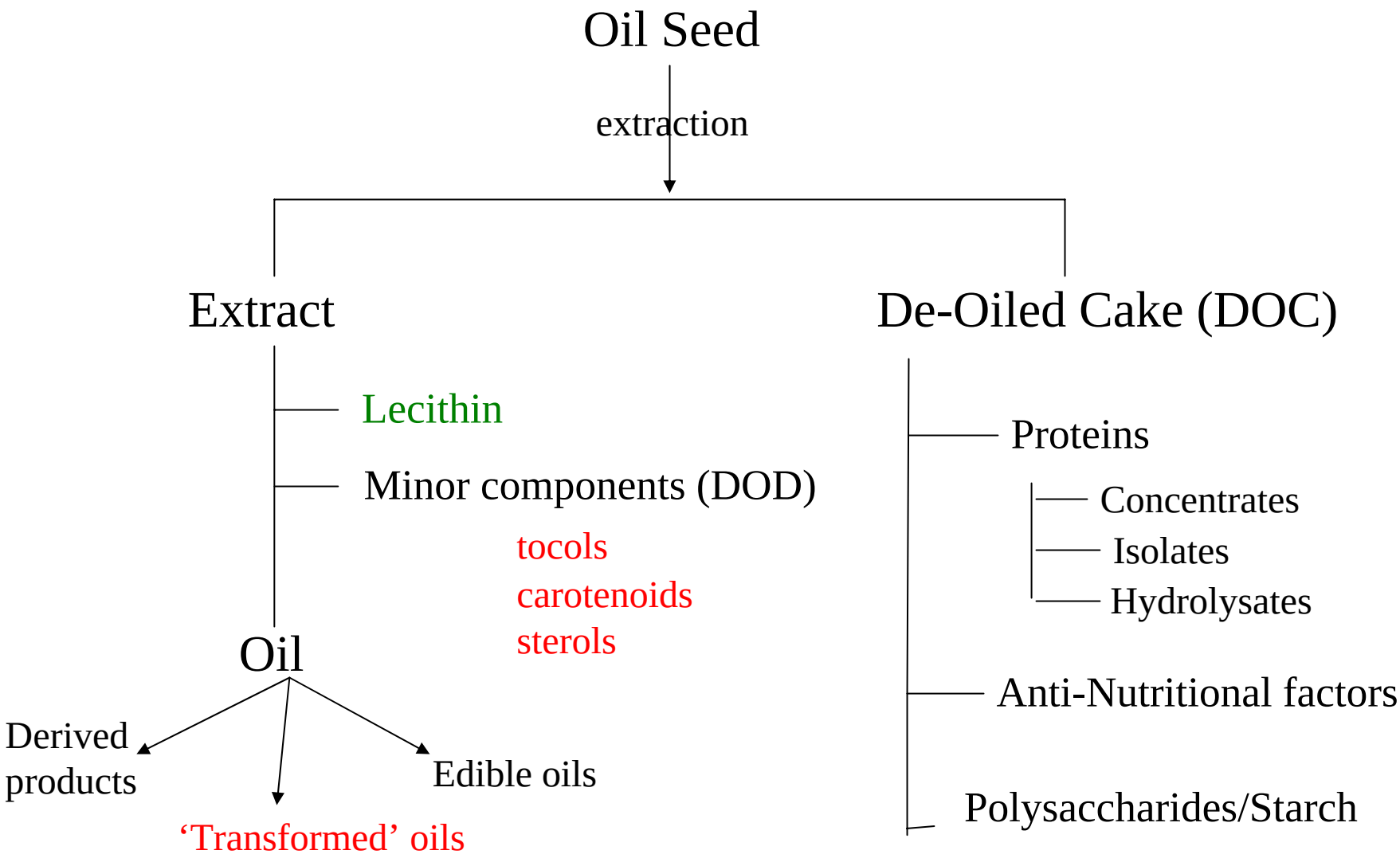
- Metabolomics and Metabolic Engineering
- Fermentation Technology
- Enzyme Technology
- Separation Technologies
- Bioinformatics and Molecular modeling

BioRefinery Technologies
Developed at
DBT-ICT Centre for Energy Biosciences

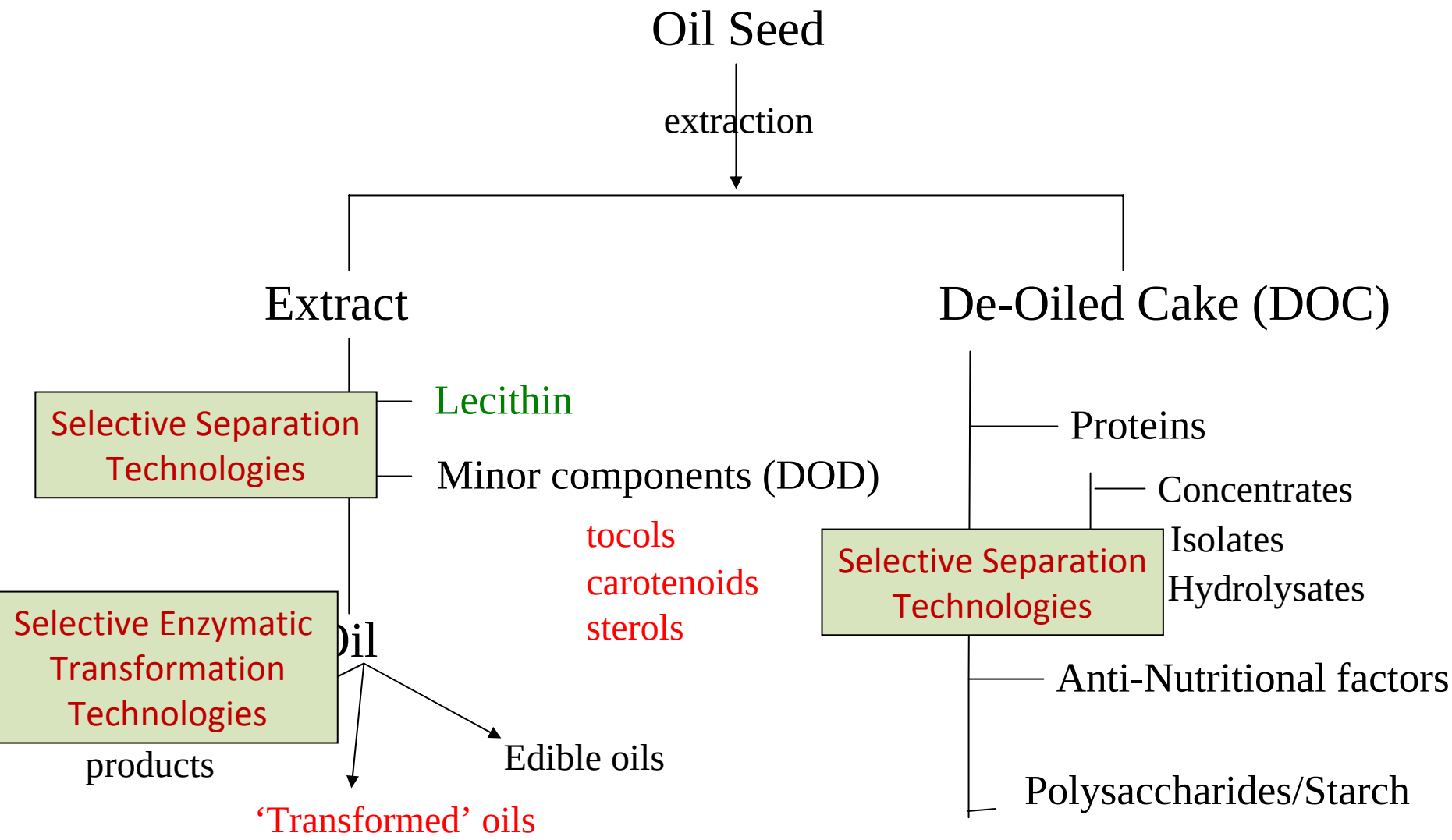
Sugar BioRefinery



Vegetable Oil BioRefinery



Vegetable Oil BioRefinery



Selective Separation Technology

Isolation and Purification of minor constituents

REPORTED METHODS

- **Saponification followed by Solvent Extraction**
- **Saponification followed by Molecular distillation**
- **Trans-esterification followed by extraction and distillation**

OIL IS CHEMICALLY TRANSFORMED BY

ALL OF THE ABOVE METHODS

ICT Approach : Innovations in Process Design

for

Selective Adsorptive/Chromatographic Separations

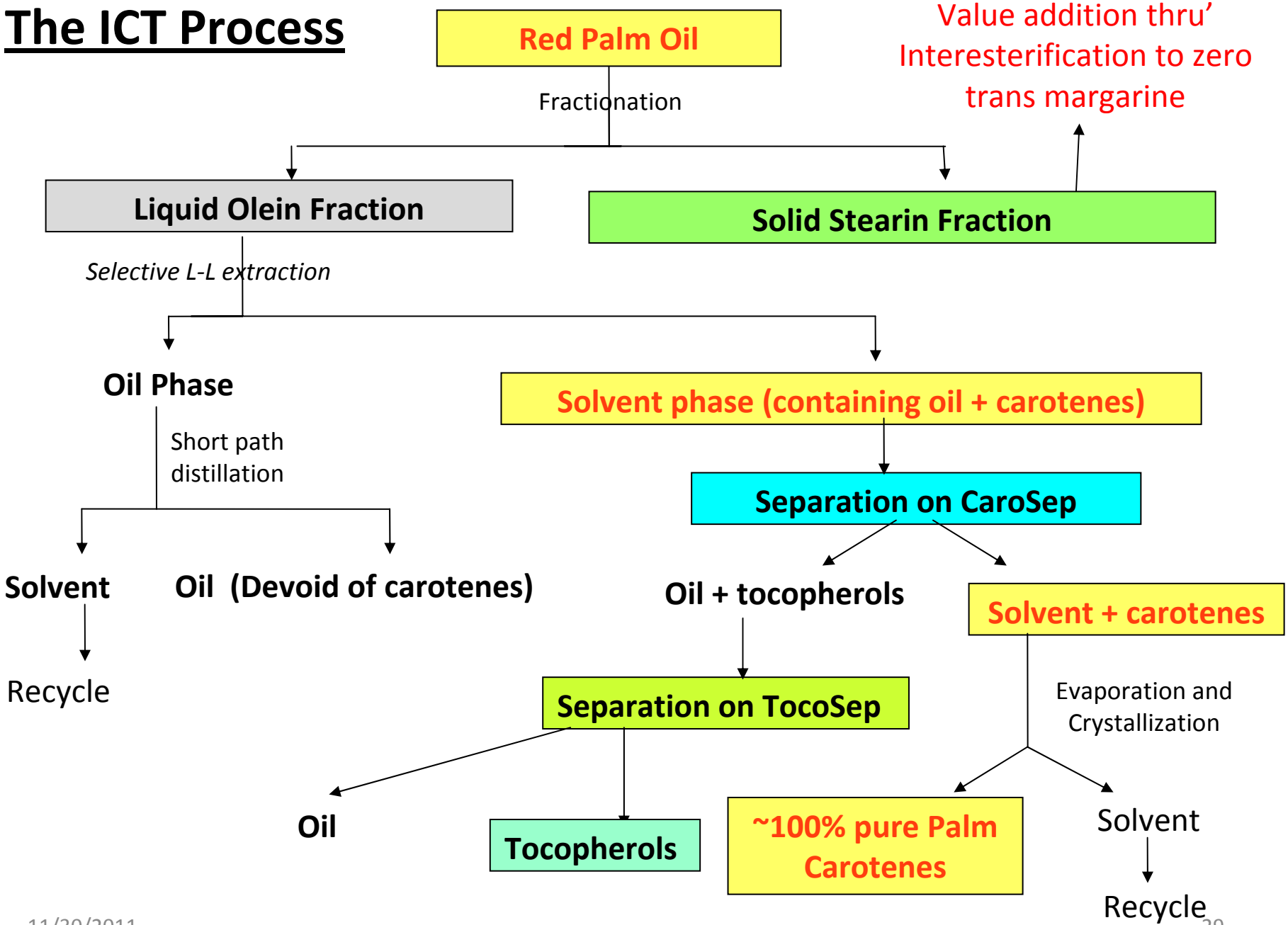
Dual Requirement :

1. **Selectivity**
2. **High Productivity/Throughput**

Selectivity → through **Thermodynamic Design**

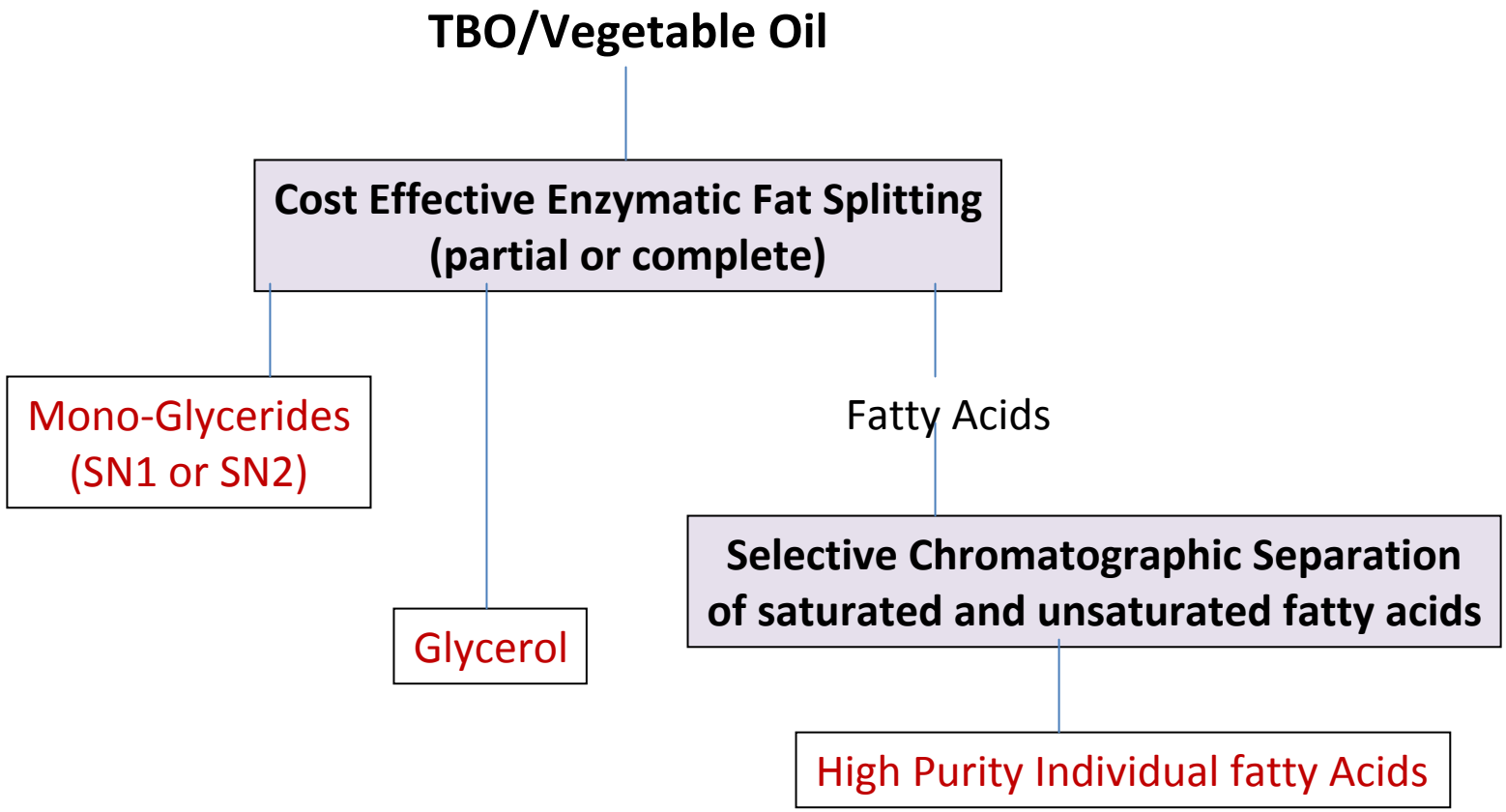
Productivity and Throughput → through **Hydrodynamic Design**

The ICT Process



Selective Biotransformation Technologies

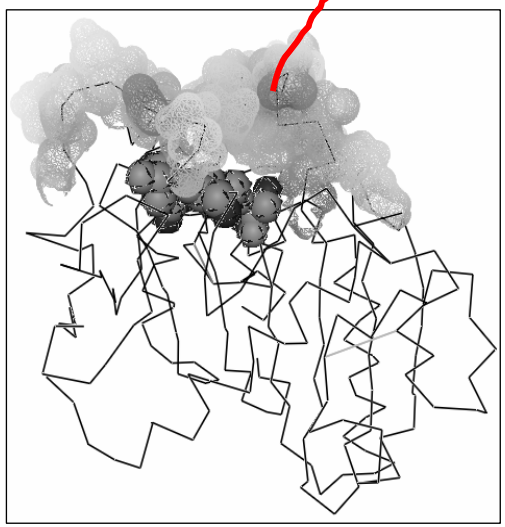
Specific Lipase Catalyzed Lipid Transformations



APPROACH : ***a) Engineered Lipase Or Hydrolytic Lipase***
b) 'Freeze' the enzyme
c) 'Immobilize' the 'frozen' conjugate in reusable form

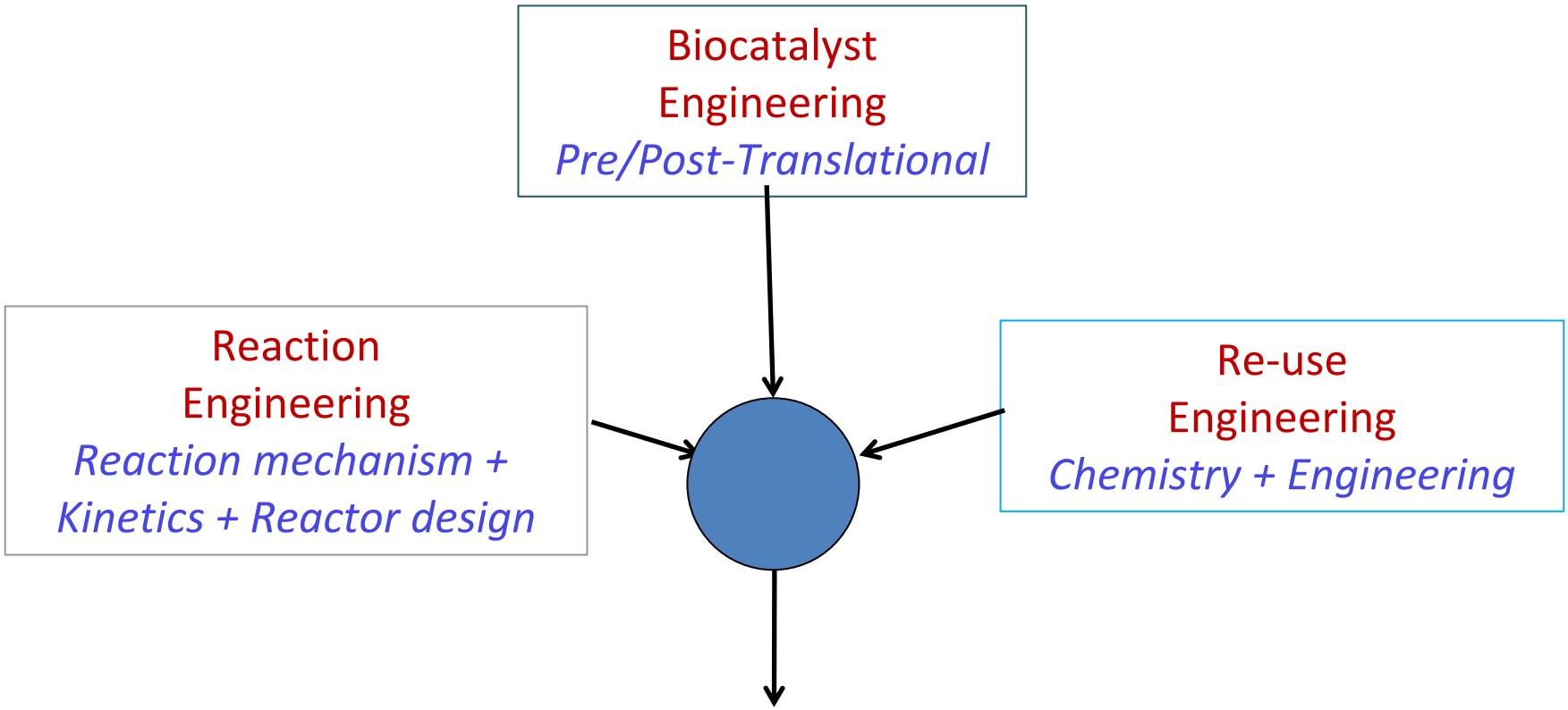
Thermomyces Lanugunosa-
Lipase – A detergent lipase

Lid deleted or pulled away to open the active site



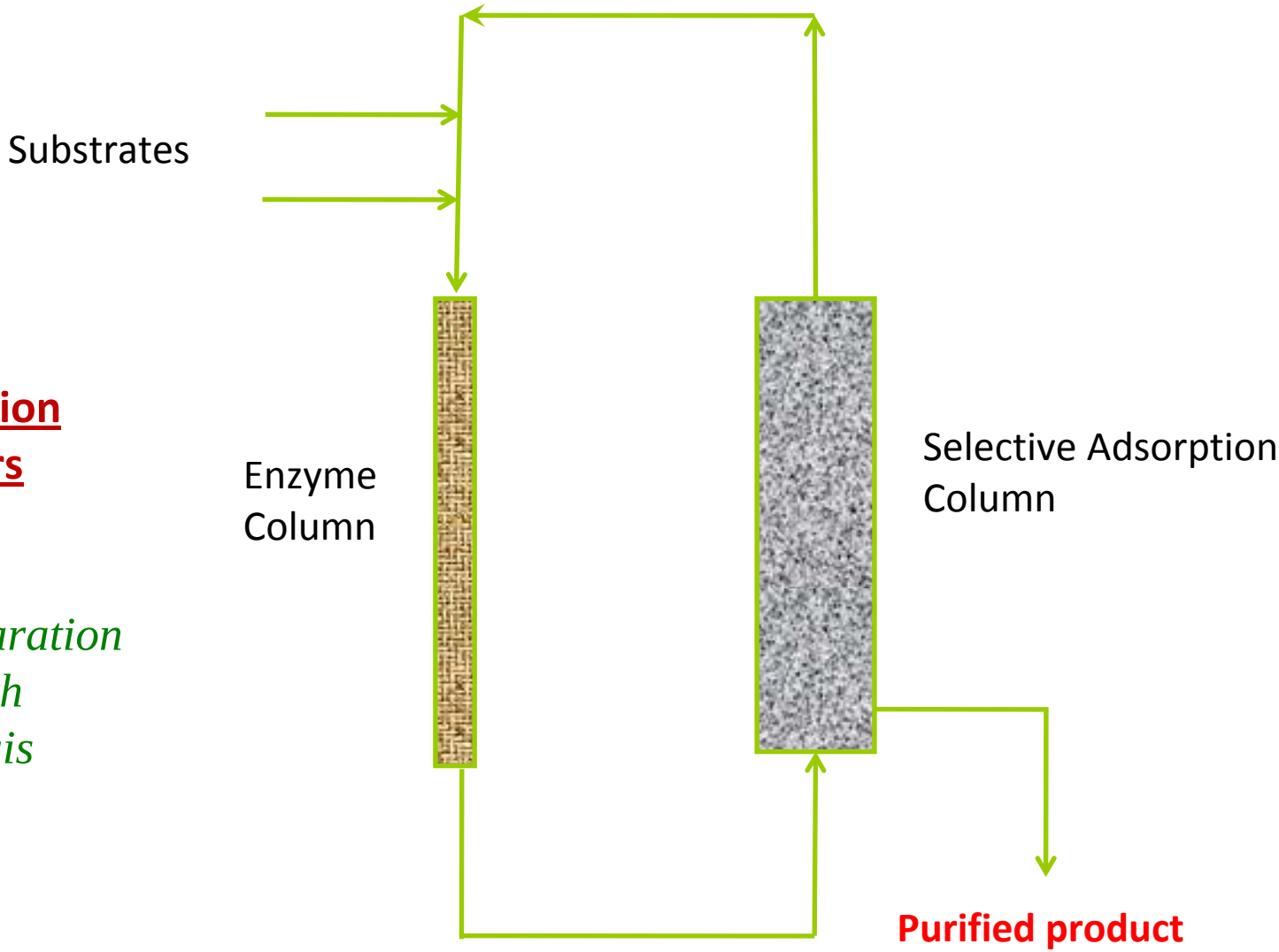
RESULT : Stable Reusable Lipase Preparations for variety of applications

Integrated Technology Approach

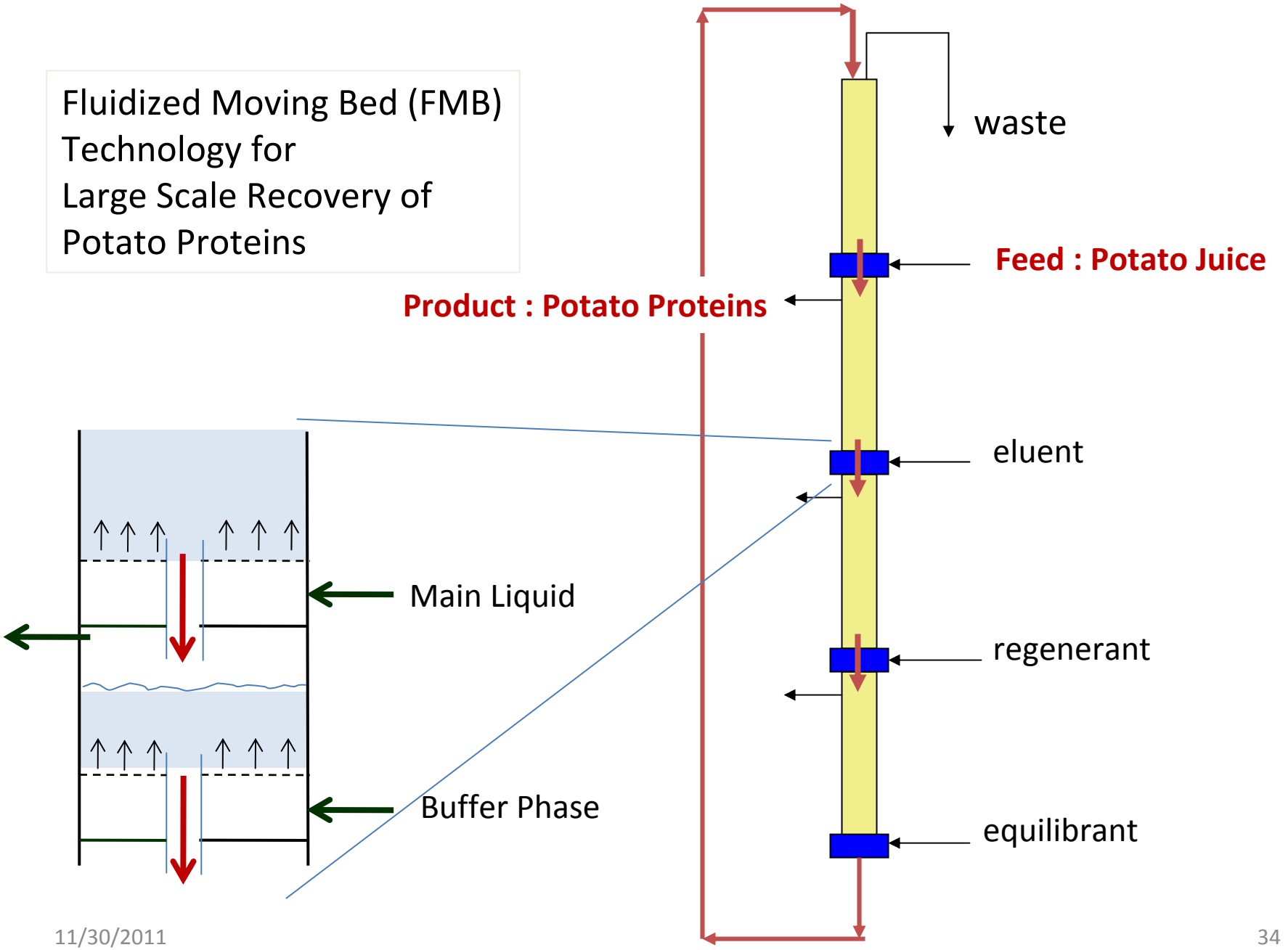


Extractive Enzymatic Biotransformation For Flavor Esters

Combining our Adsorptive Separation Capabilities with Enzyme Catalysis



Fluidized Moving Bed (FMB) Technology for Large Scale Recovery of Potato Proteins

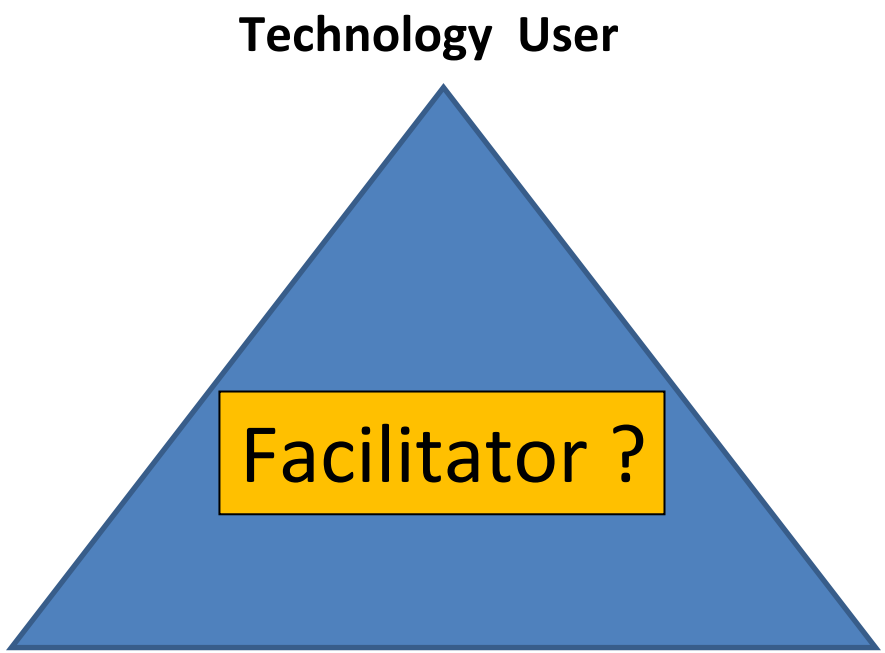


Summary

Biorefinery Concept a MUST for
Secondary Agriculture to be sustainable

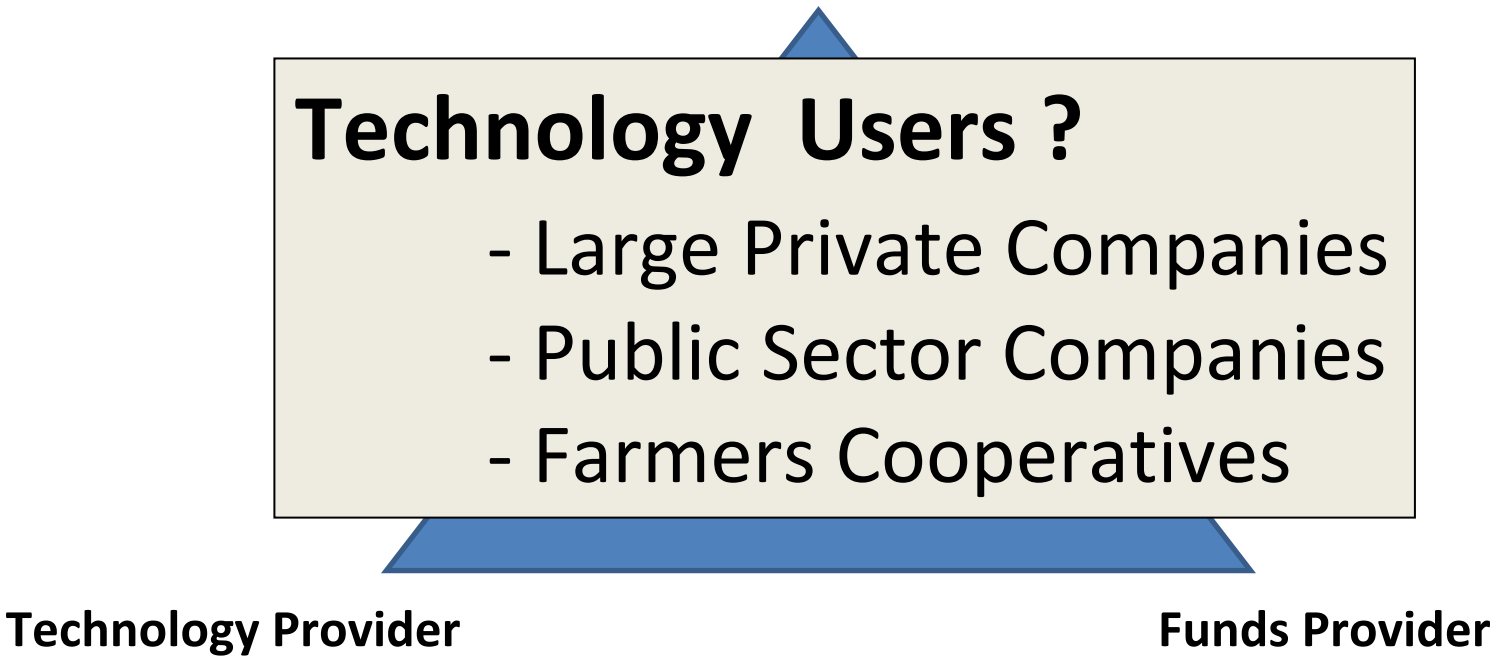
State-of-the-Art Technologies required for
Successful Biorefinery

The Secondary Agriculture Triangle



Reference : Verma Committee Report on Secondary Agriculture for Planning Commission
www.secondaryagriculture.org/

The Secondary Agriculture Triangle



Reference : Verma Committee Report on Secondary Agriculture for Planning Commission
www.secondaryagriculture.org/

Thank you