



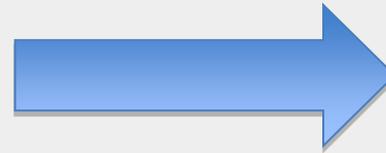
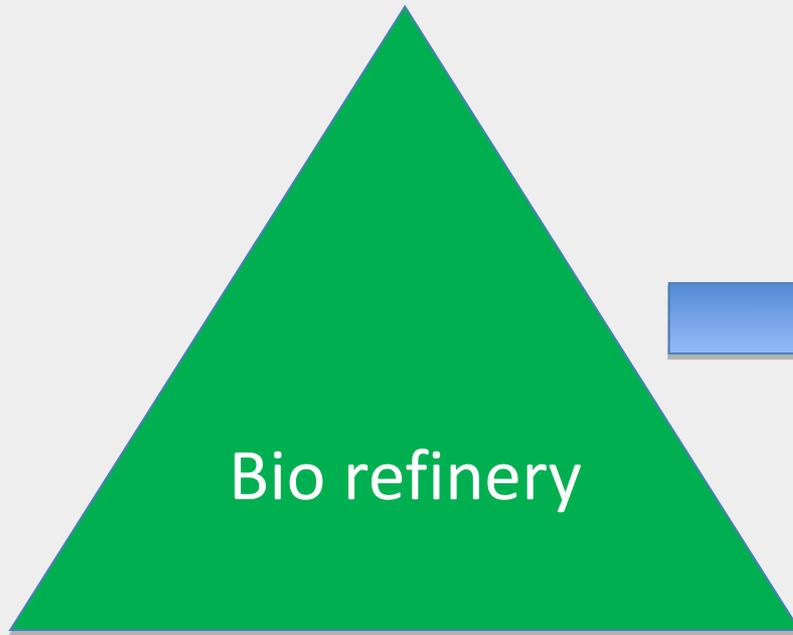
Sugar Cane Molasses : Viable Feed Stock for Levulinic acid

Agenda



- The Bio Economy
- Levulinic acid : Current Status
- Levulinic acid : Praj Process
- Conclusions
- Praj and Praj Matrix

Renewable Feedstock



Economy



Profitability
and
Sustainability

Conversion
Technologies

Fuels, chemicals and polymers

Development of Bio refinery : integral part of new Bio economy

Levulinic acid : Current Status

Chemicals : Top 12 sugar based building blocks



→ 1,4 succinic, fumaric and malic acids

2,5-furan dicarboxylic acid

3-hydroxybutyrolactone

3-hydroxy propionic acid

Aspartic acid

Glucaric acid

Glutamic acid

Glycerol

Itaconic acid

Levulinic acid

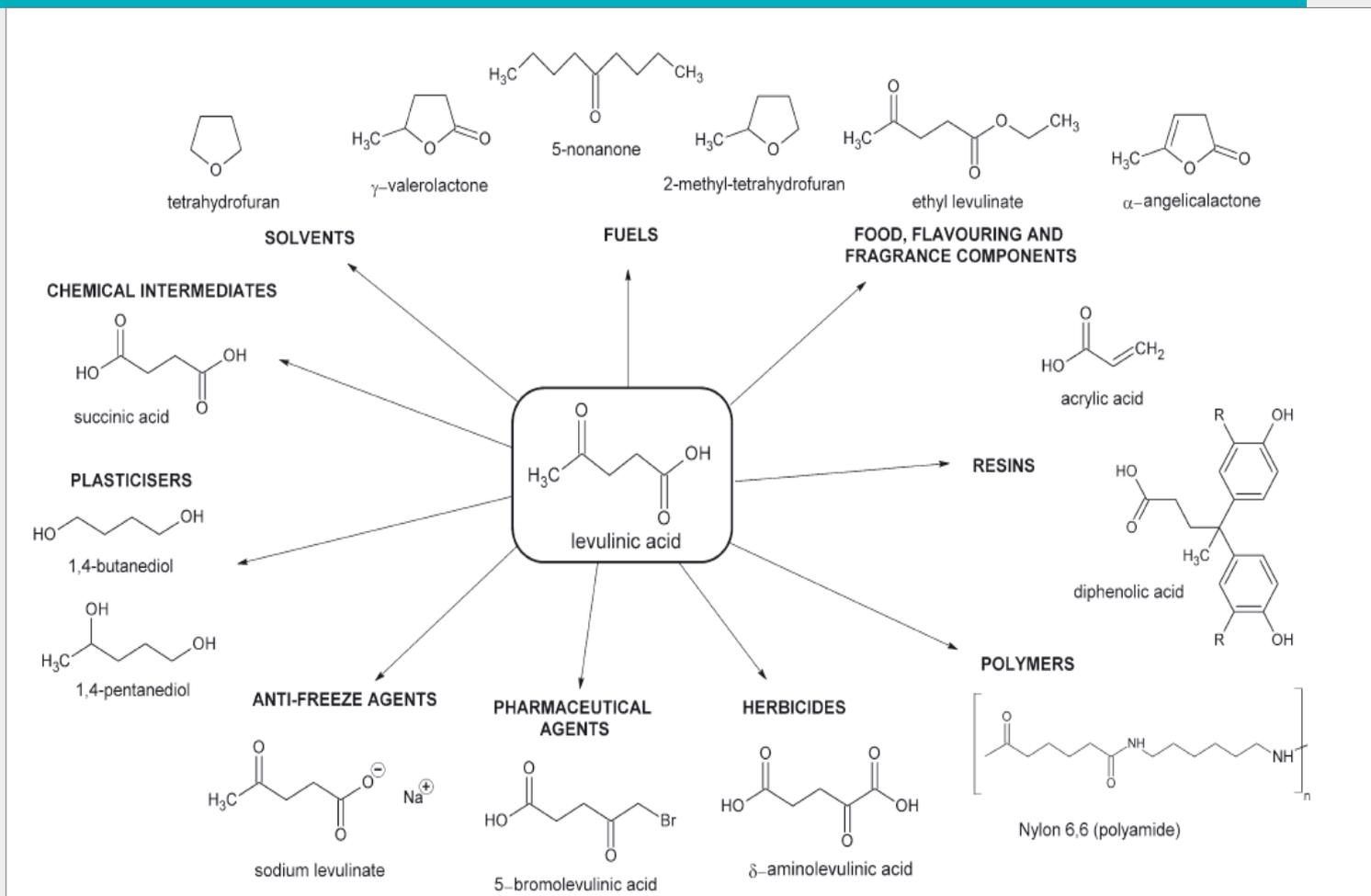
Sorbitol

Xylitol/arabinitol

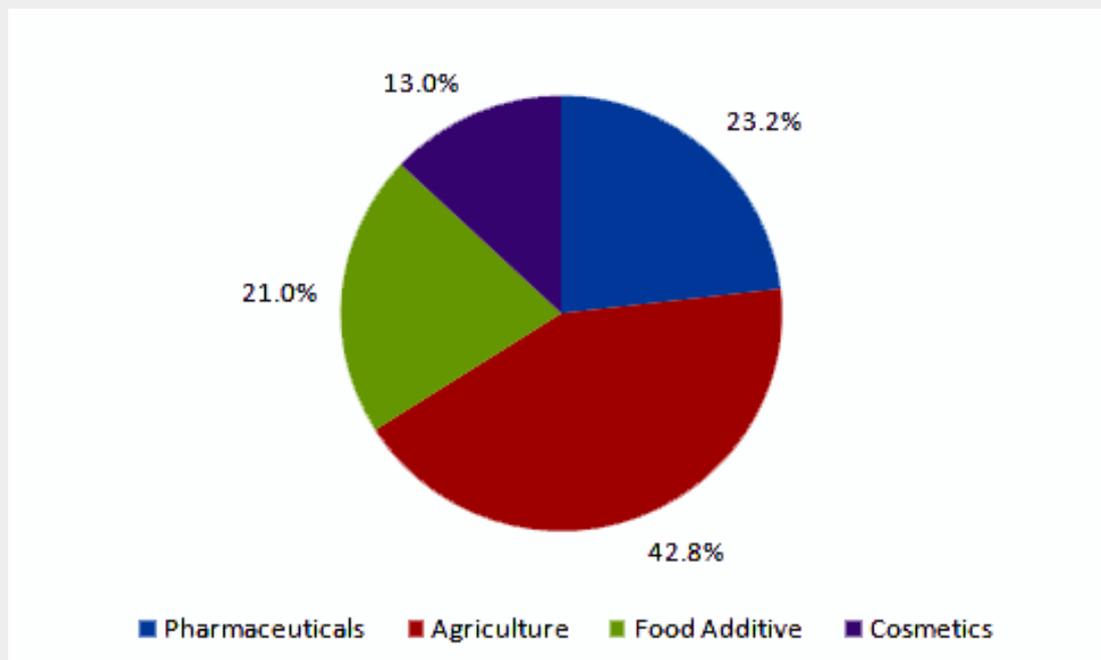


What is common to all these molecules??

Why Levulinic acid ?



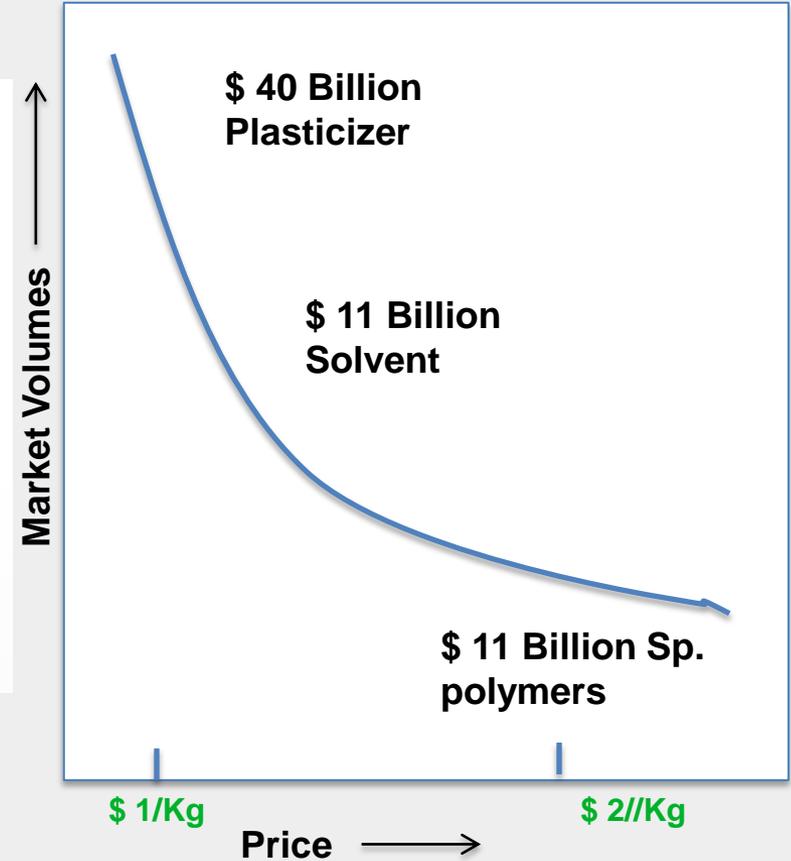
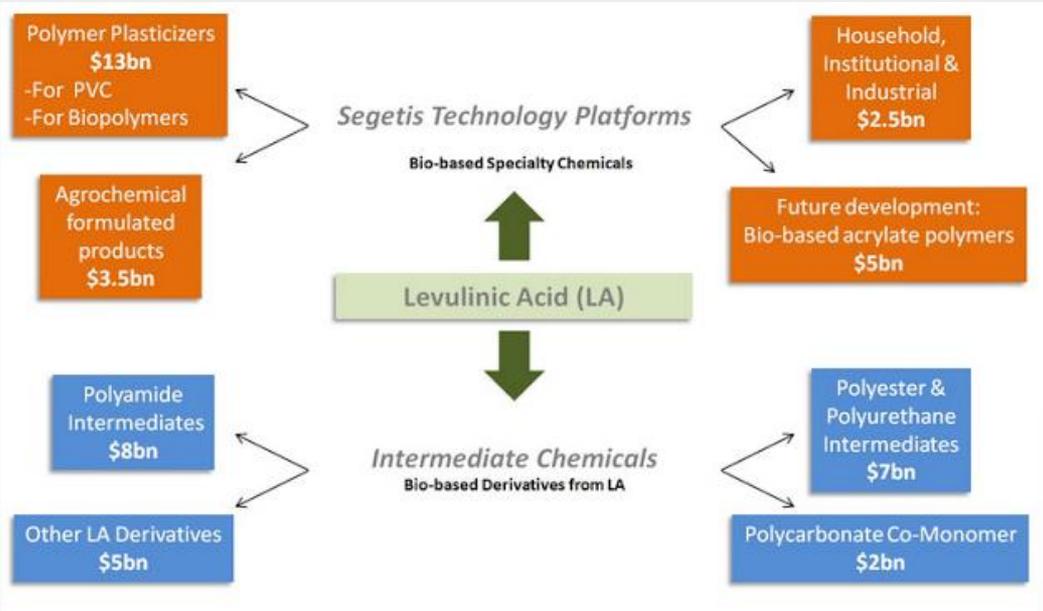
Levulinic acid - Market share by application (current)



- Current traded volumes : 3000-3500 MTA
- Major supplier : China
- Price : \$4-7 per kg

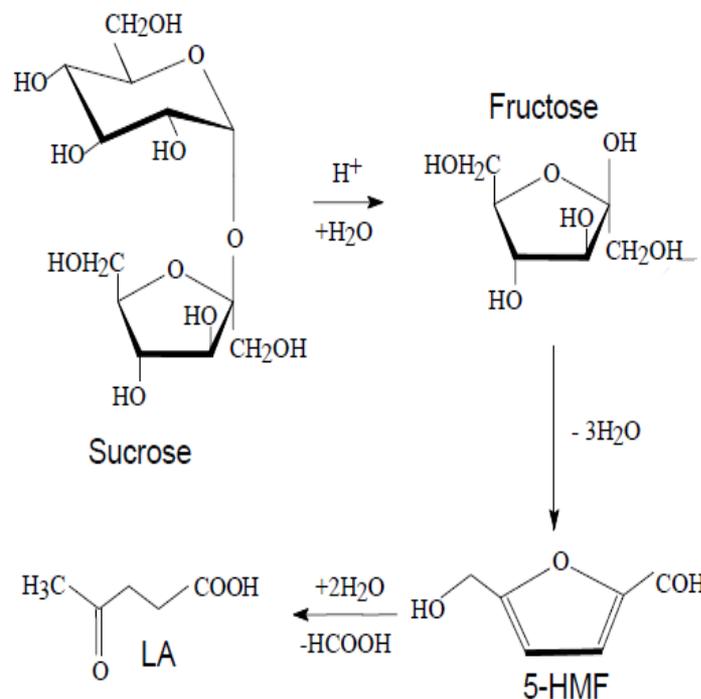
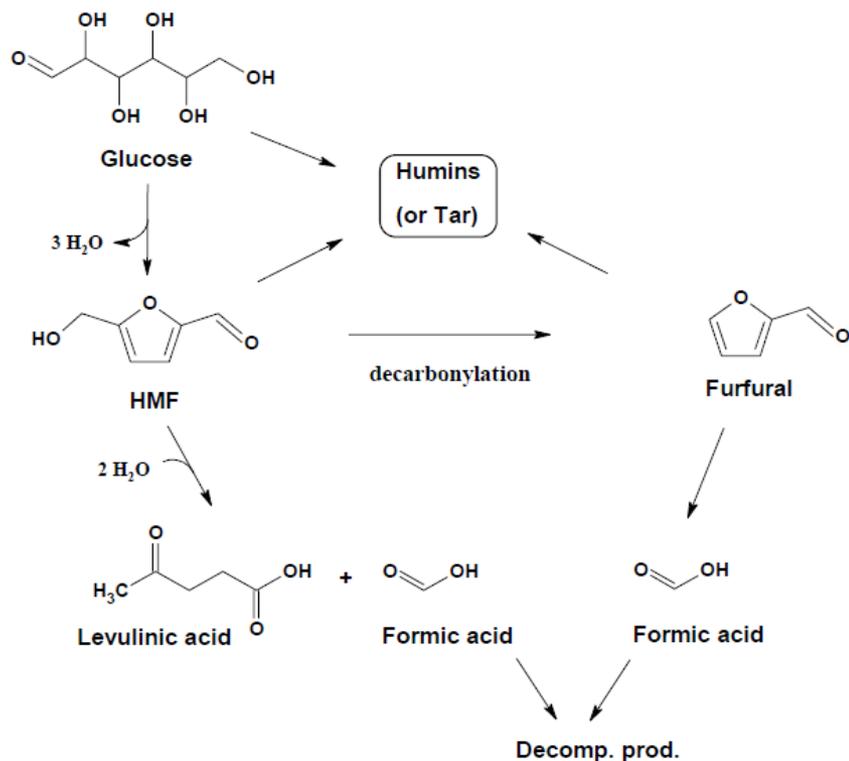
High price deterrent for market expansion

Potential Market Opportunity



Replacement potential of 50 million MTA worth US\$20 Bn if produced at <\$1/kg

Levulinic acid - Reaction Pathways



First synthesis reported in 1840 by Prof. Mulder

Levulinic acid - Challenges

- **Feed stock :**
 - Sugars : Glucose, Fructose, Sucrose
 - Food vs chemical
 - Biomass (LC)
 - Complex
 - Higher sugar costs
- **Conversion technology :**
 - Strong mineral acid catalyst
 - High temperatures
 - Low yield
 - Formation of humins/char
 - Reactor fouling
- **Separation :** Difficult to separate LA from acid, humins and formic acid
 - Equipment Fouling

Challenge to commercialization



Identification of right feedstock

Feedstock	Advantages	Challenges
Starch	<ul style="list-style-type: none"> Single sugar – Glucose Clean Easy access Available in quantities 	<ul style="list-style-type: none"> Low yields Competing with food
HFCS	<ul style="list-style-type: none"> Good yields Clean feedstock Available in quantities 	<ul style="list-style-type: none"> Cost Competing with food Poor selectivity on Glucose part
Biomass	<ul style="list-style-type: none"> No competition with food Abundant availability 	<ul style="list-style-type: none"> Higher cost of fractionation and obtaining sugars Huge CAPEX
Molasses	<ul style="list-style-type: none"> Low cost Easy access Available in quantities Non competing with food 	<ul style="list-style-type: none"> High Inorganic impurities Mixed sugars – different kinetics

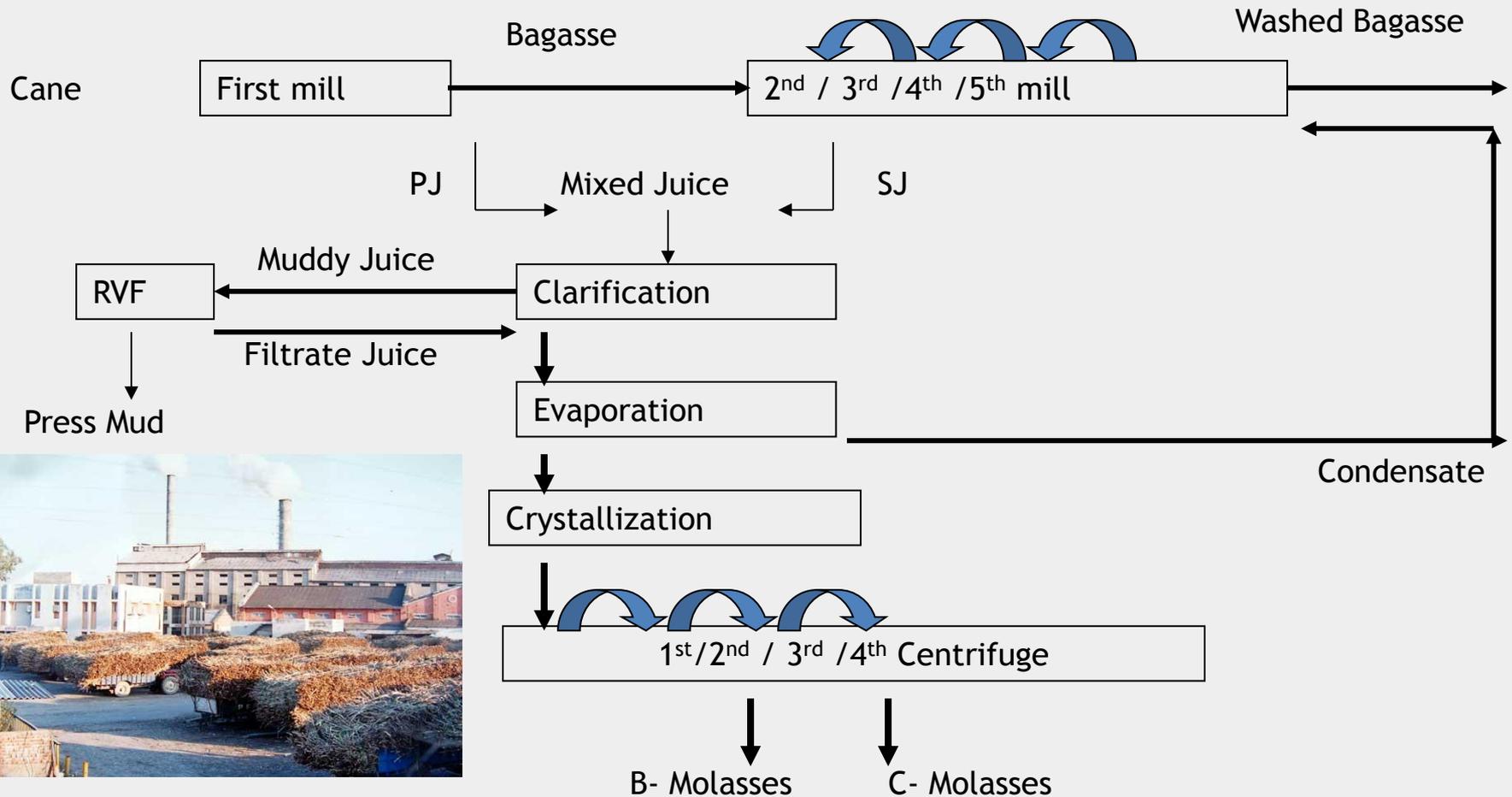
Current Technologies



Technology	Feedstock	Status
Segetis	Current feedstock – HFCS	Pilot facility of 80TPA operating in Minnesota since Oct 2013. Commercial scale target 22 MPPA (funding from IRRRB and Dept of Agri.)
GF Biochemicals, Caserta, Italy	Carbohydrate feedstock	Currently operating a continuous process pilot with capacity 2000 TPA LA (??) Plan to set up a plant with capacity 10,000TPA LA by 2015, eventually 40,000TPA LA by 2018.
Biofine	Variety feedstock @ pilot; Manufacturing with Waste Cardboards.	Pilot on variety of feedstocks for several years @ 1MTPD dry biomass Commercial plant expected to be in service by Q42015 based on waste cardboard. Capacity – 125 dry feed TPD. Estimated CAPEX - \$5.5 PAG; OPEX - \$2.44 per Gallon

Levulinic acid : Praj Process

Feed stock : Sugar Cane Molasses



Sugar Cane Molasses : Composition



Organic Solids 60 to 70 %

Sugars

35 to 55 %

- Sucrose
- Glucose
- Fructose

Other Sugars

3 to 5 %

- Pentose
- Xylose
- Arabinose

Non Sugars

15 to 25 %

- Carbohydrates
- Polymers
- Starch
- Gums
- Proteins
- Wax

Organic acids

- Acetic
- Butyric
- Propionic
- Valeric

Coloring Matter

- Caramel products

Inorganic Solids 10 to 20 %

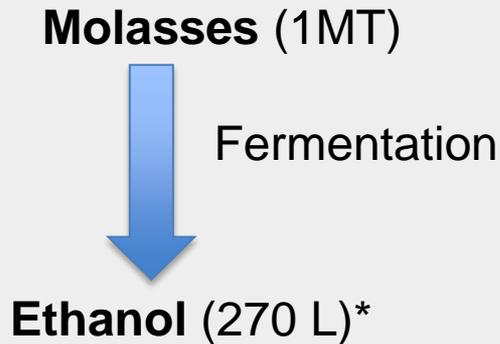
Cations

- Calcium
- Potassium
- Sodium
- Magnesium
- Silica
- Iron
- Manganese

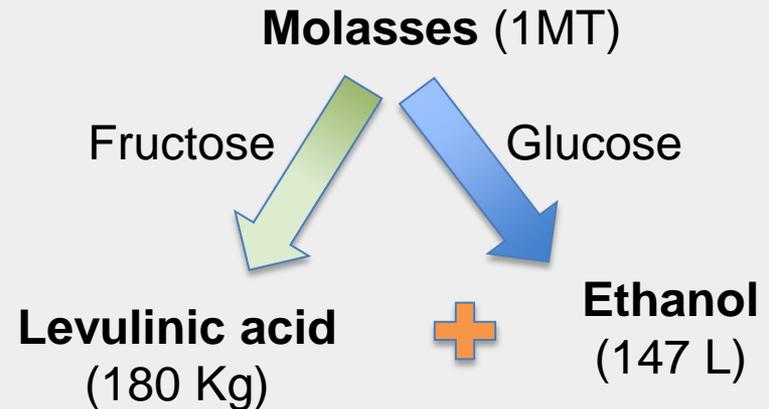
Anions

- Sulfates
- Carbonates
- Phosphates
- Chlorides
- Nitrates
- Oxides

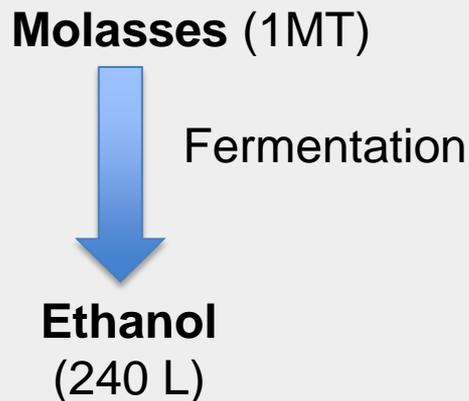
Conventional Ethanol distillery



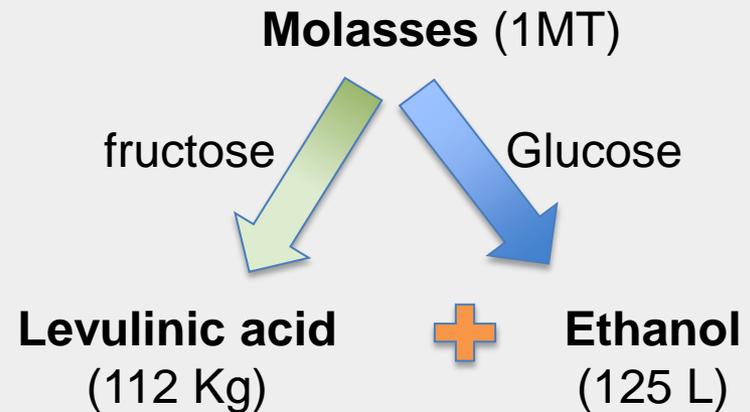
Value Addition Proposed (Theoretical)



Conventional Ethanol Distillery

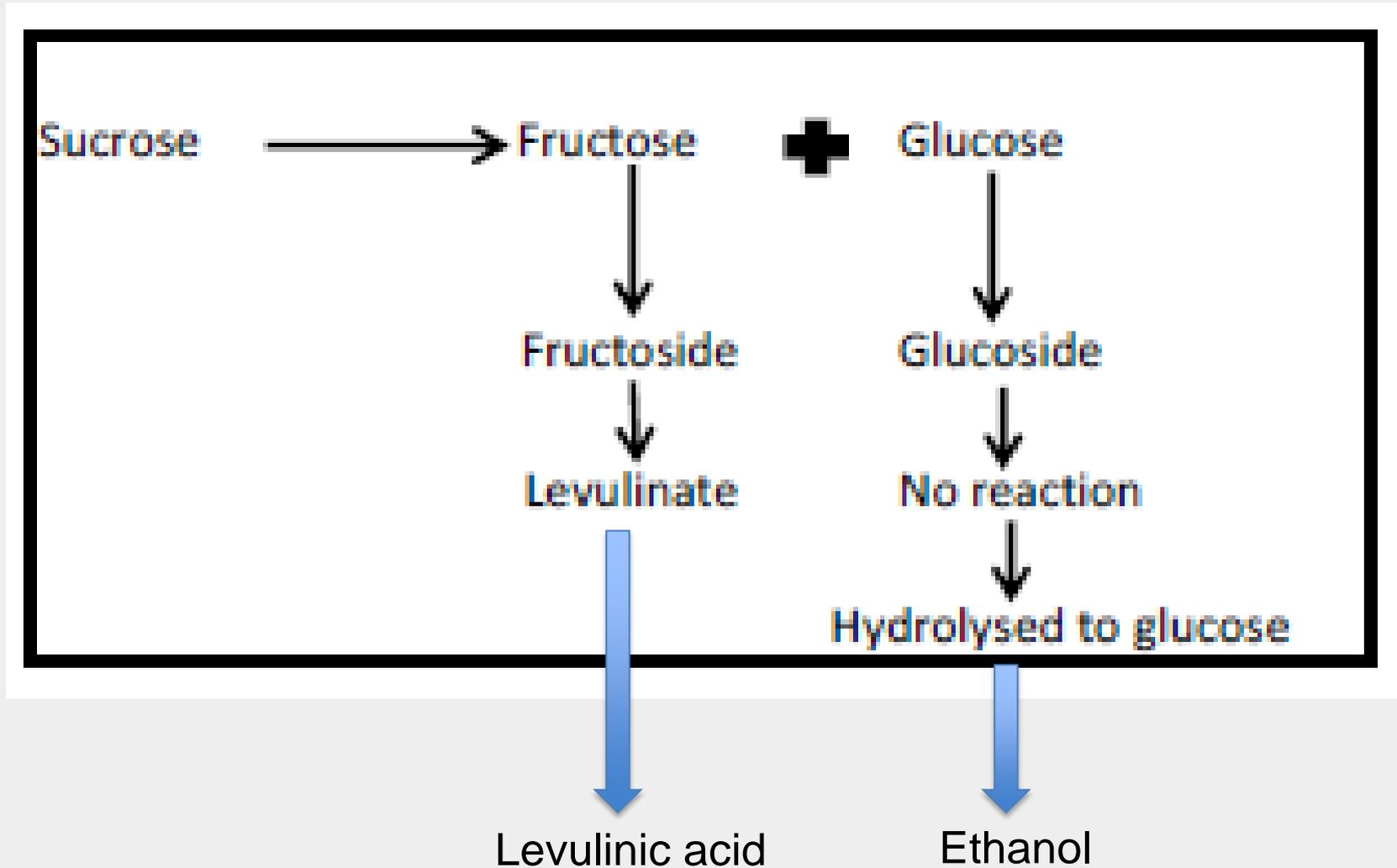


LA+Ethanol



Better Value addition (three times) than Ethanol alone

How this happens?



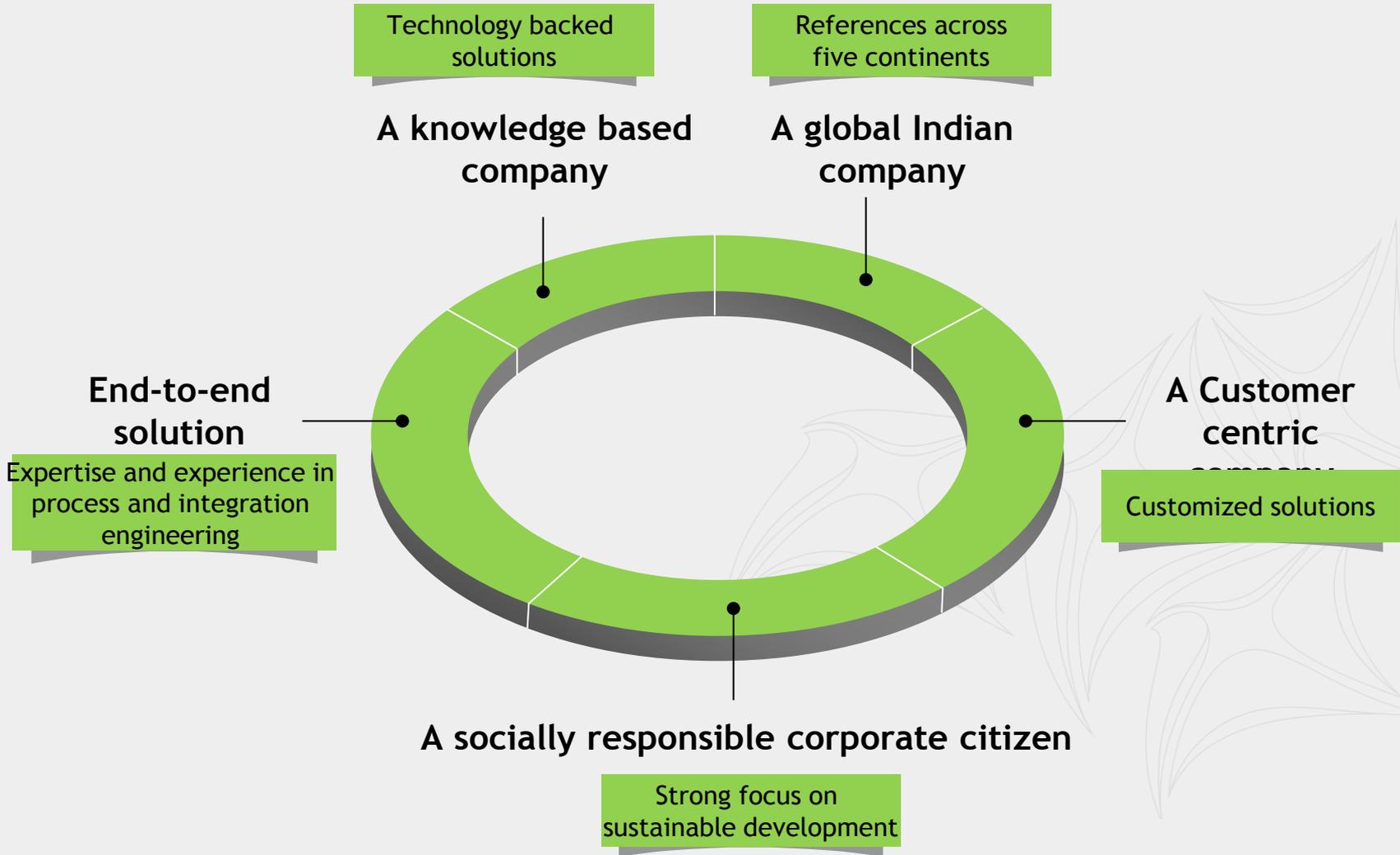
Salient features of new process



- Use of low cost molasses as feedstock
- Fructose to Levulinic acid yield ~ 70%
- Recovery of glucose >95% (clean stream with less inorganic salts)
 - Faster fermentation , higher alcohol concentration, yeast and spent wash recycle - possible in molasses fermentation
- Clean process
- Technology ready for piloting
- Bolt on to existing molasses based ethanol plants for better value addition
- Novel route patent application filed

Praj and Praj Matrix

Who we are



What we do



-Alcohol/
Ethanol plants
-Brewery
plants

Water and
Wastewater
Treatment
Systems

Critical
Process
Equipment &
Systems

HiPurity
Systems

- Pharma
- Biotech
- F&B
- Cosmetics

Bio-Products

- Distillery
bioconsumables
- Livestock, health
& nutrition
products
- Human health &
nutrition
- Biochemicals

- Innovate, Integrate and Deliver
- 600 references in 60 countries across globe

Over 600 refernces





- ❑ 80,000 sq ft of Labs, Pilot Plants, and Offices
- ❑ 94 technologists 20 PhDs, 65 Masters
- ❑ 4 Technology COEs
 - Biology, Chemistry, Engineering
- ❑ 16 Labs with clean room facility
- ❑ ISO-9001-2008 Analytical Labs
- ❑ Pilot Plants
 - 1 tpd Cellulosic Ethanol pilot plant
 - Multipurpose biochemicals pilot plant

Bench and Pilot scale facilities enable validation of scientific assumptions and rapid commercialization

Praj Matrix : Business and Collaboration Models

Business Model



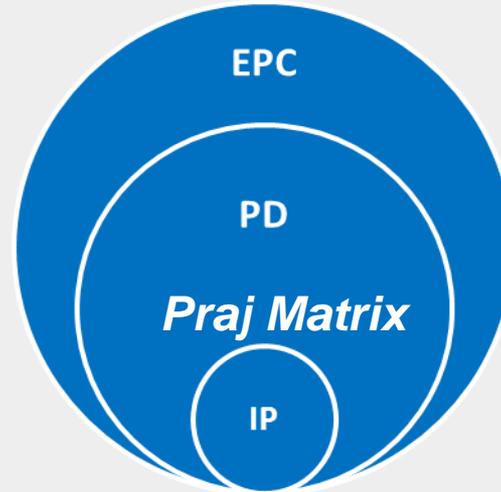
Feedstock

Technology

Customer

Who

Oils,
Sugars,
Biomass



Large
&
Mid-sized
End Users

Scope

Feedstock Owner Buys
Technology + EPC

Own
Manufacturing

End User Buys
Technology + EPC

Upstream Alliance: Offer Technology, EPC,
Operating Support

Downstream Alliance: Offer Technology
EPC, Operating Support

Fully Integrated Alliance: Offer Technology, EPC, Operating Support
Alliance also gets Supply & Offtake Commitment

Joint Development

- Sharing Resource
- Sharing IP
- Sharing Knowledge

Process scale up and optimization

- Process POC @ Bench Scale
- Partner invests for scale up and optimization

CRSS

- Process Development
- Process scale up
- Partner spends and owns IP
- Praj works on specifics

Partnerships for sustainable future

We believe in providing environment friendly, sustainable solutions that can make the world a better place

Thank you

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