

# **AgriBio smart Chemical Production System (ABCS) Processes and Products**

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# Acknowledgment

**Council for Science, Technology and Innovation (CSTI)**

**Cross-ministerial Strategic Innovation Promotion Program (SIP): Technologies for smart bio-industry and agriculture**

**National Agriculture and Food Research Organization (NARO)**

**Dr. Noriaki Kobayashi (Program Director)**

**Dr. Wataru Mizunashi (Sub-program Director)**

**Cooperative Research Program of Network Joint Research Center for Materials and Devices  
(Kyushu University, Hokkaido University, Tohoku University, Tokyo Institute of  
Technology, Osaka University)**

## **ABC consortium**

**consists of 17 institutions plus collaborators.**

**Kyushu University (*representative*)**

**Akita Prefectural University, Kagoshima University, Kyoto University,**

**Nagaoka University of Technology, Tohoku University,**

**Akita Prefectural Livestock Experiment Station,**

**Akita Research Institute for Food and Brewing (ARIF),**

**The National Agriculture and Food Research Organization (NARO),**

**The National Institute of Advanced Industrial Science and Technology (AIST),**

**Japan Bioindustry Association (JBA),**

**DKS Co. Ltd., Fuji Oil Holdings Inc., Kao Corp.,**

**Mizuho Information Research Institute Inc., Shinko Sugar Co., Ltd.,**

**Toray Industries, Inc.**

**Collaborators: Akita prefecture and more than 10 Japanese private organizations.**

# Background 1

## Bottleneck

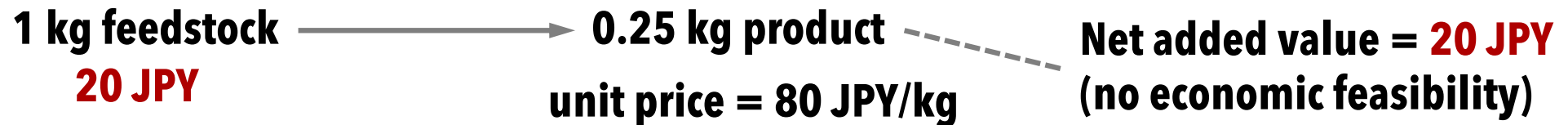
- in implementation of bio-based chemical production
- in supply chain from bioresource to chemical products

## Difficulty

- in stable supply of C6/C5 mono-sugars at price as cheap as 30 JPY/kg

## Problem

- mono-production (e.g., sugar only, ethanol only) and low 'net' recovery
- small 'net' total added value of products against feedstock
- many sell-buy points in supply chain



## Solution

- To convert **all of major/minor chemical components** into **chemicals/materials** (cellulose, hemicellulose, lignin, isoprenoids, polyphenols, silica)
- At **maximized yield/recovery**
- To realize **multi-production** of chemicals/materials

$$\frac{\sum (\text{Product added value, net})}{\text{Added value of feedstock}} > 10$$

- To **integrate/unify the supply-value chain** ranging from feedstock to chemicals/materials for external sales **at business level**

# ABCS system overview

**Agri-bio feedstock** Rice straw, rice husk and Giant Miscanthus (Ogi-susuki), Food residue

**Sequential harvesting-collection-storage-stabilization**

**Separation of chemical components and functionalization with water and ethanol**

**Isoprenoid, agri-pulp (H/L purities), silica/lignin composite, xylo-oligo sugar, xylose**

**A variety of chemical & biochemical processes in series or in parallel**

**C6 sugar**

30 JPY/kg

**Cellulose nanofiber, Nano-cellulose, high-purity silica  
Lignin monomers, Silica/carbon nano composite,  
C5/C6 sugar esters/ethers, Agri-pulp resin, C18:1-rich oils,  
Yeast residue (fish feed/enrichment), Lower organic acids,  
Anhydrosugars (levoglucosan, levoglucosenone)  
Isoprenoids/poly-phenols for healthcare/skincare**

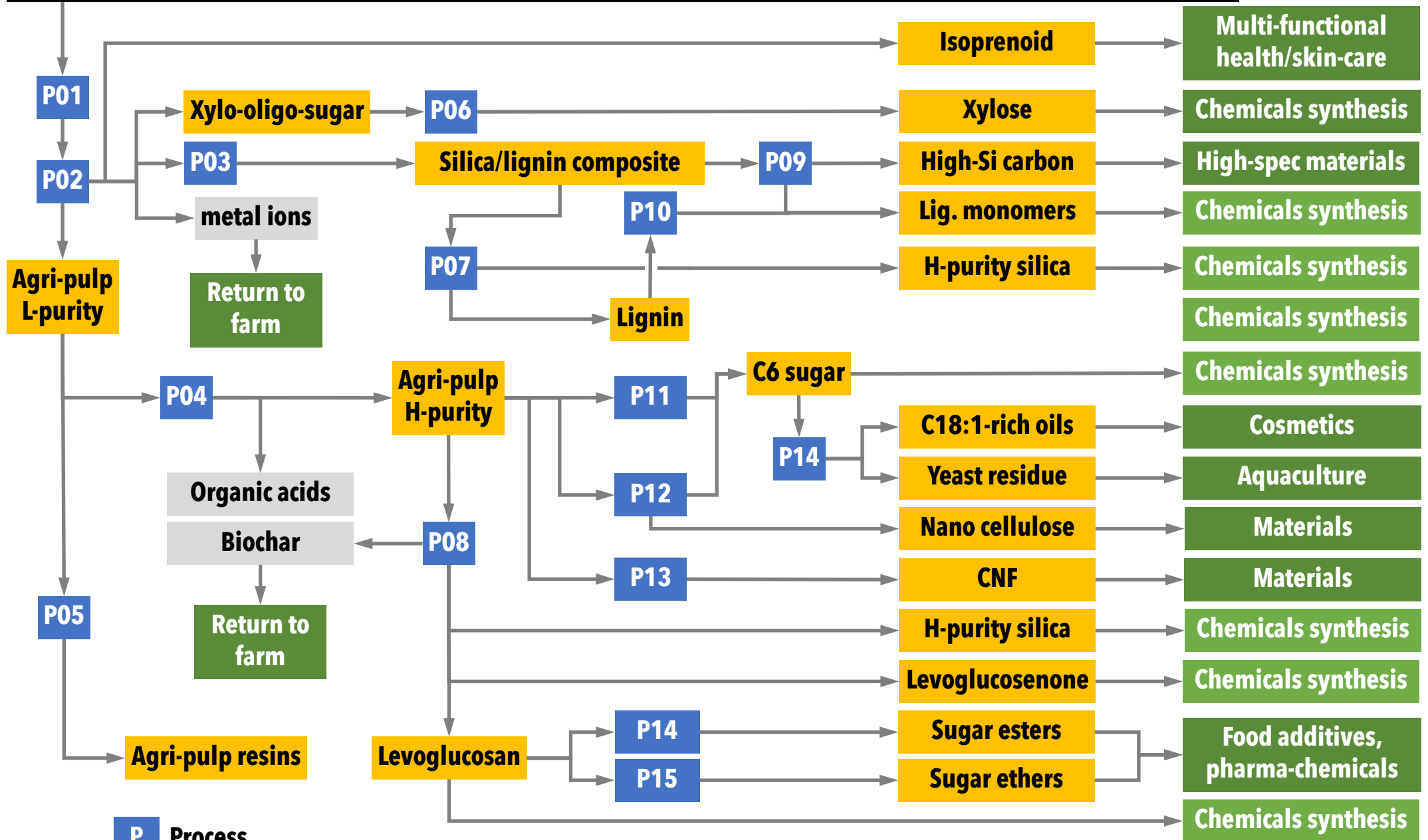
**Market**

**Market**

**Only one, cheaper and/or higher spec.**

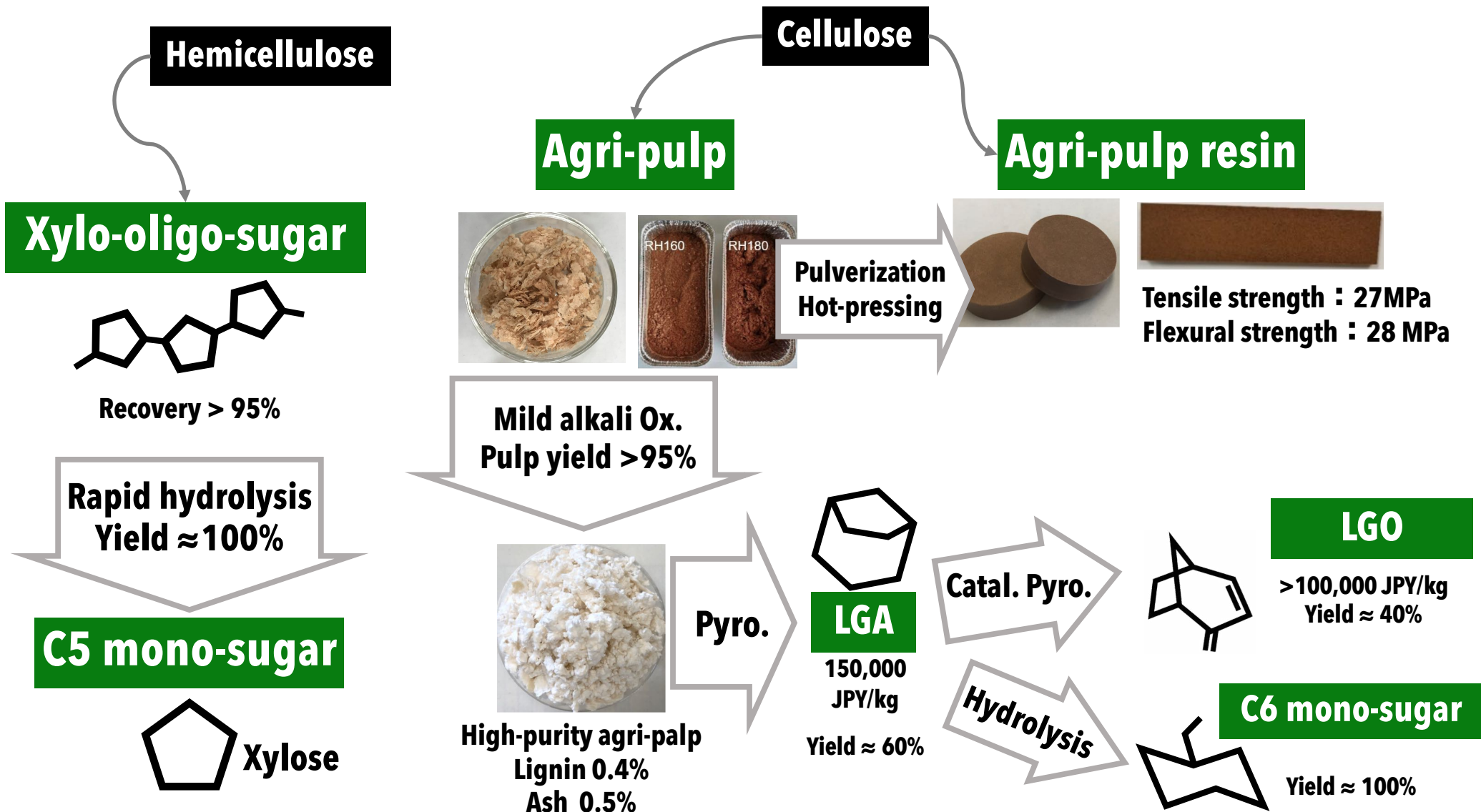
# ABCS system overview

Agri-bio resource (feedstock) Cellulose, hemicellulose, lignin, isoprenoids, polyphenols, silica and other minor's



# ABCS Products

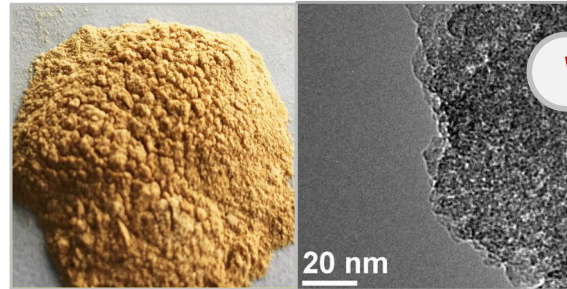
## Multi-stage extraction with warm/hot water in percolator





# ABCS Products

**Silica/lignin  
molecular composite**

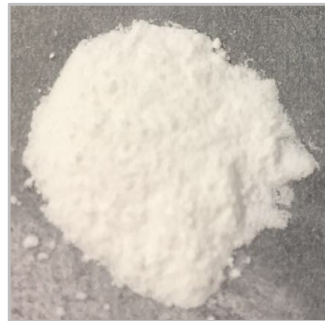


**World's first and only one**

**Hot-water extraction &  
oligo-sugar removal**

**Precipitation, Re-dissolution, Pyrolysis  
Carbonization, Combustion**

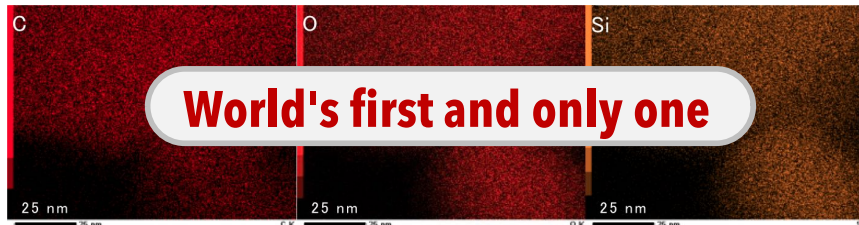
**High purity silica  
Nano silica  
Mesoporous silica**



**Purity > 99.9X%**

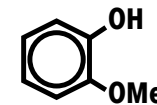
**High silica carbon**

**Nano-composite  
(e.g., anode material for Li-ion battery)**

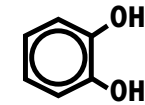


**World's first and only one**

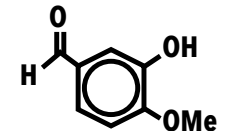
**Phenols**



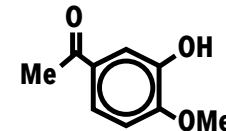
Guaiacol



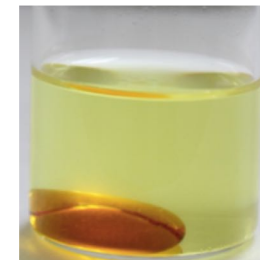
Catechols



Vanillin



Apocynin



**Monomer selectivity ≈ 100%  
New pyrolysis process**

**World's first and only one**

# ABCS Products

## Ethanol/water + isoprenoids



**Bactericides**  
**Antibacterial**  
**Antiviral**  
**Antioxidant**  
**Anti UV**  
**Aroma/fragrance**

Consumer monitoring (2020)



Healing, improving dementia

**World's first and only one**



Cedar leaves



Rice straw/husk

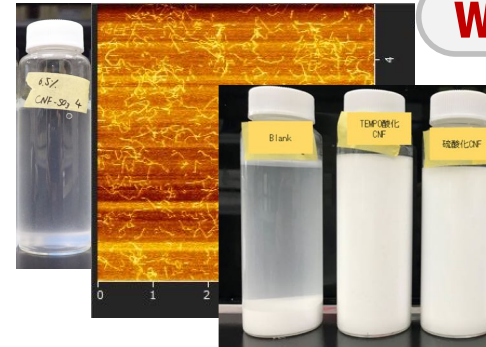


Fungus bed waste

## Cellulose nanofiber (CNF)

Introduction of a particular type of functional groups

**World's first and only one**

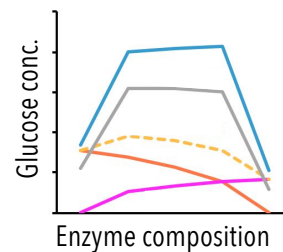
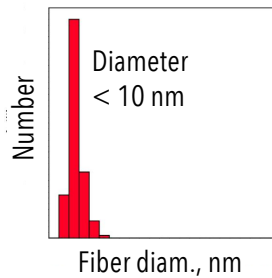
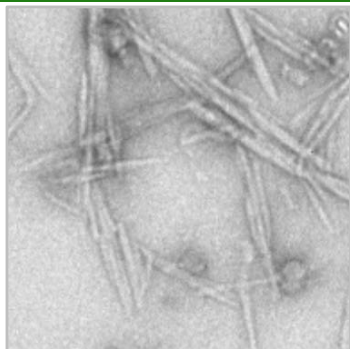


Equivalent to/better than TEMPO CNF

- Viscosity thickening
- Adsorption
- Water retention
- Emulsification
- Particles dispersion
- Coating

**Application: Environmental & agricultural materials**

## Glucose/nano-cellulose Coproduction



**Enzymatic saccharization simultaneously with nano-sizing of cellulose fibers**

## Low-cost enzymatic saccharization

Agri-pulp (Rice straw & husk)



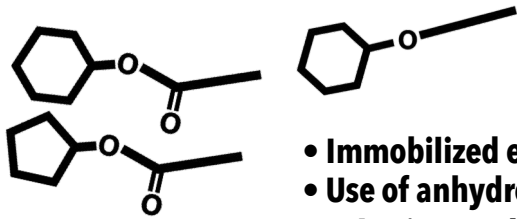
**Demonstration of saccharization of agri-pulp**

**Target: 30 JPY/kg-sugar (fixed & variable costs)**

# ABCS Products

## C5/C6 Sugar esters/ethers

**World's first and only one**



- Immobilized enzyme catalyst
- Use of anhydro-sugar
- Selective production of alpha ether

## Giant Miscanthus (Ogi-susuki)

Finding Newlines with rapid growth (X2 - X4)  
Wet storage

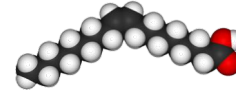


Utilization of abandoned/wasted lands

**Variety registration**

2020: Demonstration of silage preparation  
2020: demonstration field tests

## C18:1-rich oil and spent yeast



C18:1 selectivity > 60%

**INCI registration**

Cosmetic ingredients

Spent yeast



Aquaculture  
Feeds/additives

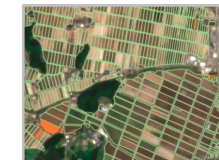
## Rice straw

**Demonstrated**



Harvesting → Sun Drying → Wet storage → Washing/cleaning

Total cost  
19.8 JPY/kg-dry



Maximization of  
harvesting/collection

## Agri-biomass gasification & power/heat production

- 2020: Start of demonstration PJ
- Coproduction of power and silica



# Advantage of ABCS

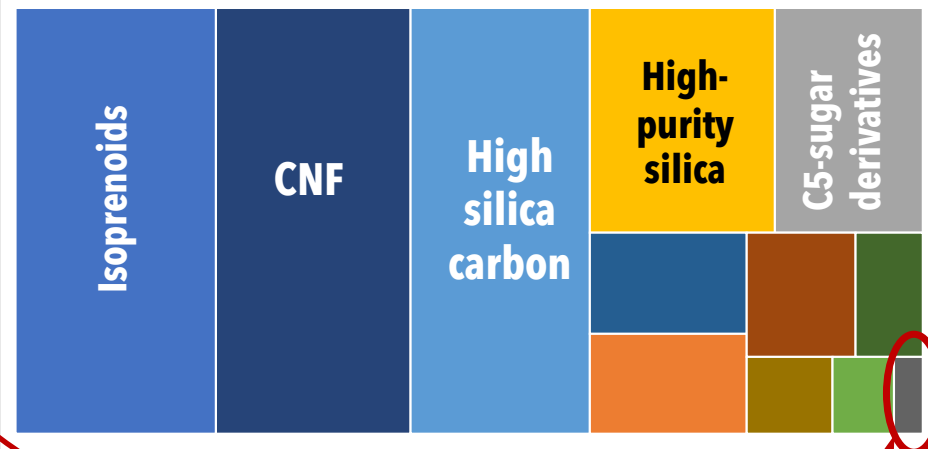
- Production of chemicals/materials from All the chemical components with high recovery (yield)
- Integration of not only processes but also supply chain at business level (elimination of sell/buy of feedstock and intermediate products in the supply chain)



**Highly competitive  
in the global market**

Product	Yield kg/100 kg	Unit price JPY/kg	Net value JPY/100 kg
Isoprenoid	0.5	20,000	10,305
C5 mono/oligo-sugars	19.0	100	1,897
C5-sugar derivatives	4.0	1,000	4,000
High-purity silica	5.0	1,000	5,000
High-silica carbon	9.2	1,000	9,200
Lignin monomers	2.8	200	568
CNF	10.0	1,000	10,000
Nano cellulose	5.5	300	1,638
C6 mono-sugar	8.9	30	268
Anhydrosugar (AHS)	4.0	200	800
C6-sugar derivatives	3.8	500	1,911
AHS-derivatives	1.0	1,000	1,000
<b>Total</b>	<b>73.7</b>		<b>46,587</b>
Feedstock cost, JPY/100 kg-dry	2,000		
<b>Product/feedstock value ratio (net)</b>	<b>23.3</b>		

- Isoprenoids
- C5-sugar derivatives
- High silica carbon
- CNF
- C6 mono-sugar
- C6-sugar derivatives
- C5 mono/oligo-sugars
- High-purity silica
- Lignin monomers
- Nano cellulose
- Anhydrosugars (AHS)
- AHS-derivatives



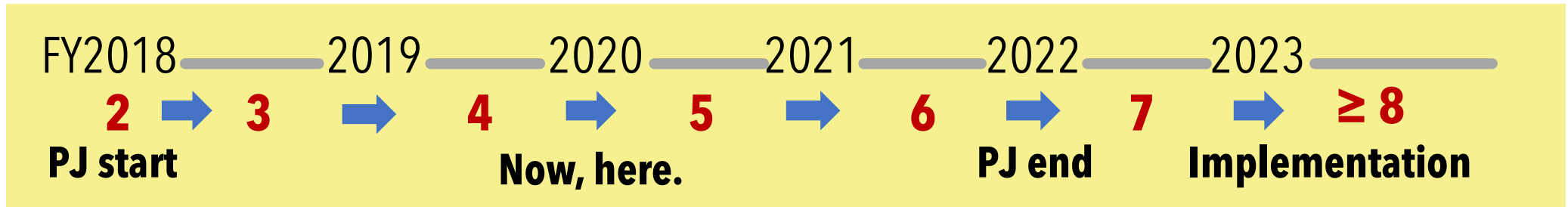
**P/F value ratio (net)**

**FY2018 : 4.5~11 ▶ FY2019 : 16 ▶ Now : > 20**

**C6 mono-sugar**

# Schedule

## R/D schedule (expected **TRL** improvement)



**2022 - Implementation of some processes (**partial** implementation)**

**2023 - **Full** implementation (incl. planning)**

**Improvement of not only technical but also **business/market** readiness levels**



# Future Prospect

## First target of Implementation



**Yokote/Akita**



## Agricultural areas in JAPAN



**'Interlocal'  
collaboration  
Feedstock sharing**



## Agricultural areas in the world



# To audience

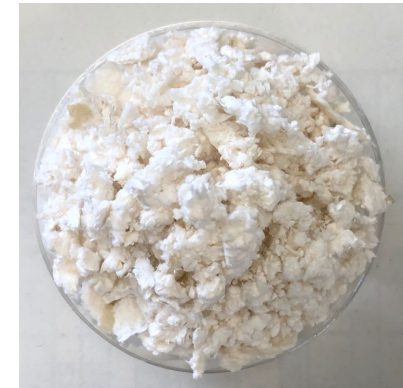
**If you are interested in our intermediate products, we can supply them.  
We will start operation of kg-scale percolator.**



**High purity silica**



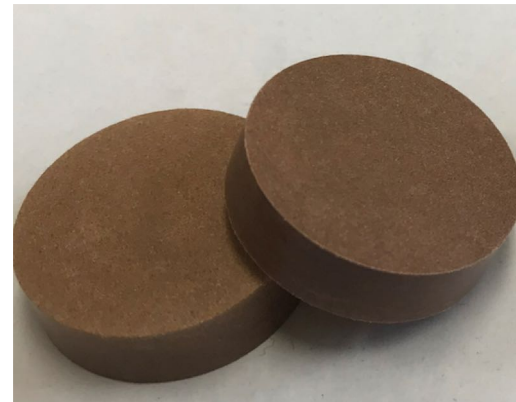
**Silica/lignin composite**



**Agri-pulp (rice straw/husk)**



**Xylo-oligo sugar**  
Major chemical unit: xylan



**Hot-pressed  
low purity agri-pulp**