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Overview of Post-harvest Loss Reduction and Processing Technology of Cassava in China

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Sharing for Learning

Expert's Profile

Prof. Zhenwen ZHANG

Research area: post-harvest physiology and proteomics

- Deputy Director of National Cassava Processing Technology R&D Sub-center
- Head of Cassava Engineering Department of National Tropical Crops Engineering Technology Research Center
- Post Expert of National cassava industry technology system post-harvest treatment and processing
- Expert of Hainan Province Science and Technology 110 project
- Research and development on plant physiology (photosynthetic physiology and post-harvest physiology) and post-harvest processing and integrated utilization technologies for cassava, an important tropical crop

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General Information

General Information

Cassava is the sixth largest food crop in the world, the main food for nearly one billion people in the world's hot regions, and important raw material for the starch, alcohol and feed industries in China.

- In China, there are four advantageous production areas: "Gui East - Gui South, Gui West - Yunnan South, Guangdong East - Min West Gan East, Qiong West - Guangdong West", among which Guangxi has outstanding advantages.
- Planted area of 4.57 million acres, production of 5 million tons (CCARS, 2022)

General Information

Leaf: The main vegetable in cassava growing areas in Africa and Southeast Asia, with an annual trade volume of about 400,000 tons, rich in protein, minerals and flavonoids.

Stems: The main propagating material for cassava cultivation, rich in fiber, minerals and tannins; about 250 million tons of cassava stems (about 95%) are unused and wasted every year worldwide.

Fresh / Dried Cassava: Rich in starch, the global annual trade volume of 12 million tons (dried chips), about 80% of the trade is distributed in Thailand, Vietnam and Indonesia in Southeast Asia, China is the main importer and consumer of dried cassava chips and raw starch.

General Information

◆ Cassava leaves

Cassava leaves are important by-products of cassava production, rich in protein (22.0%, DW), comparable to the crude protein content of dry grass (22.5%), but with high biomass and high metabolic energy, they are high-quality raw materials for animal feed. It is reported that cassava grows for about 8 months, and 18.3 tons of fresh stems and leaves can be harvested per hectare, with an annual yield of 40.0 tons/ha/year.

	Dry matter		Crude protein		Metabolic energy	
	%	t/ha/year	%	kg/ha/year	thermie /kg/year	thermie /ha/year
Kudzu	24	10.0	21.0	2,100	2.20	22,000
Mountain Leeches	21	4.5	15.0	675	1.90	8,550
Silver Acacia	35	15.2	25.7	3,906	1.90	28,880
Dry grass	25.8	24.0	22.5	5,400	1.47	35,280
Young Stem Leaves	**25**	**40.0**	**22.0**	**8,800**	**1.70**	**68,000**



General Information

◆ Cassava Stalks

Cassava stalks contain 4.47% crude protein, 39.32% crude fiber and 19.84% lignin, which is an ideal base material for edible mushroom cultivation. It can be used for black fungus, elm mushroom and golden needle mushroom substitute cultivation.

Base Materials	Crude Protein%	Crude Fat%	Cellulose%	Hemicellulose%	Lignin%	Nitrogen-free Leachate%	Ash%
Mixed Wood Chips	1.57	3.12	36.12	12.58	19.17	24.52	2.92
Cottonseed Hulls	5.07	1.57	32.73	21.42	15.18	18.19	5.84
Corn Cobs	2.05	0.78	30.26	34.13	17.19	13.46	2.13
Corn Stalks	3.51	0.82	32.91	31.89	14.65	11.36	4.86
Wheat Stalks	2.63	1.16	43.6	22.21	9.32	14.81	6.27
Sorghum Stalks	3.42	1.73	40.11	30.15	7.68	10.79	6.12
Cassava Stalks	4.47	0.38	39.32	11.88	19.84	21.32	2.79

Black Fungus

Elm Mushroom

Flat Mushroom

Enoki Mushroom

Apricot Mushroom

Auricularia Polytricha

General Information

◆ Fresh/Dried Cassava

The starch content of fresh/dried cassava is 60-82% (dry basis), which is an important energy source and food raw material, and its starch yield is about equivalent to the starch yield of 4 acres of single-season rice (rice at 500 kg/acre and 70% dry basis starch). Fat content and protein content of cassava dry with 0.82% and 2.56%, respectively, rich in mineral elements (potassium 1.2%, calcium 0.07%).

The use of edible cassava can be processed into a variety of products such as starch, modified starch, alcohol and food, among which the main ones for industrialized processing are starch, modified starch and alcohol.

Indicators \ Raw Materials	Dried Cassava	Fresh cassava
Starch Content (%)	75.00	25.00
Water Content (%)	13.73	64.70
Ash (%)	2.46	0.63
Fat (%)	0.82	0.25
Protein(%)	2.56	1.07
Coarse cellulose (%)	3.20	1.11
Potassium (%)	1.20	Three times the potassium content of bananas
Calcium (%)	0.07	Equivalent to red beans

General Information

◆ **Application**

In China, 90% of cassava tubers are used for alcohol and alcohol processing and 8% for animal feed processing.

纺织
Weave

食品
Food

饲料
Feed

能源
Energy sources

应用广泛
Widely used

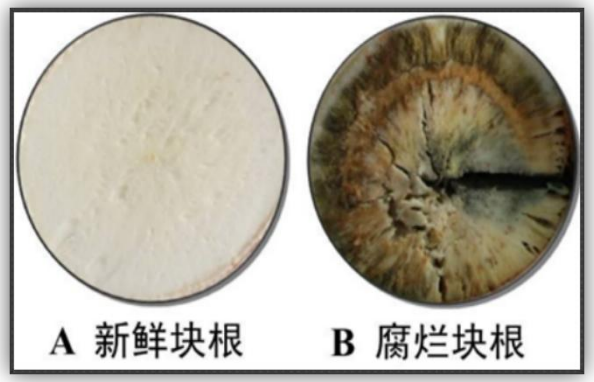
造纸
Paper making

医药
Medicine

General Information

◆ Main Post-harvest Issues of Fresh Cassavas

(1)Fresh Cassavas are easily rotten after harvesting



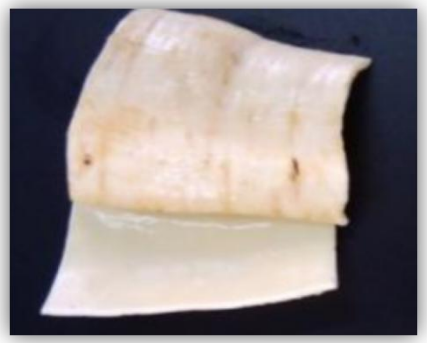
(2) Fresh Cassavas are difficult to process and peel

Artificial Peeling Situation

No.	Fresh Cassava Weight (Kg)	Cassava Weight (Kg)	Peeling Speed (Kg/h)	Fresh Cassava Utilization (%)
1	9.7007	7.4801	9.6381	77.1089
2	9.9172	7.4499	9.7874	75.1210
3	9.8010	7.1638	9.7017	73.0925
Average	9.8063	7.3646	9.7091	75.1075

Outer skin

Phloem



Xylem

02

Technology of Postharvest Loss Reduction

Technology of Postharvest Loss Reduction

- Cassava is a typical tuber crop with different varieties, production methods and preservation techniques that are closely related to post-harvest damage reduction. At present, 47 varieties have been selected

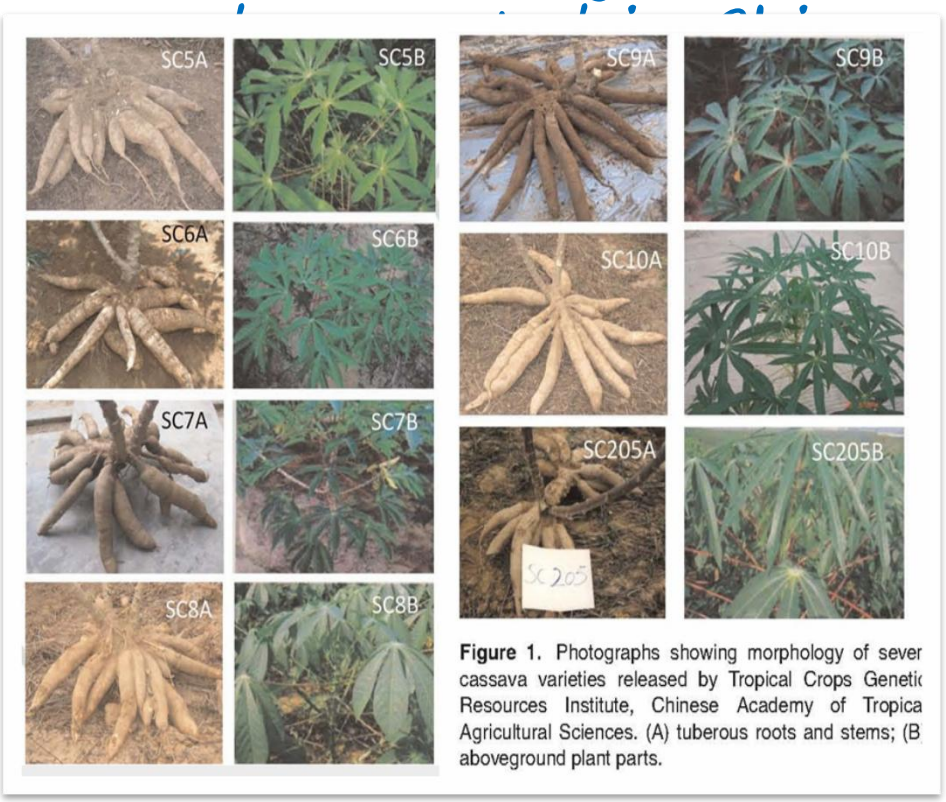


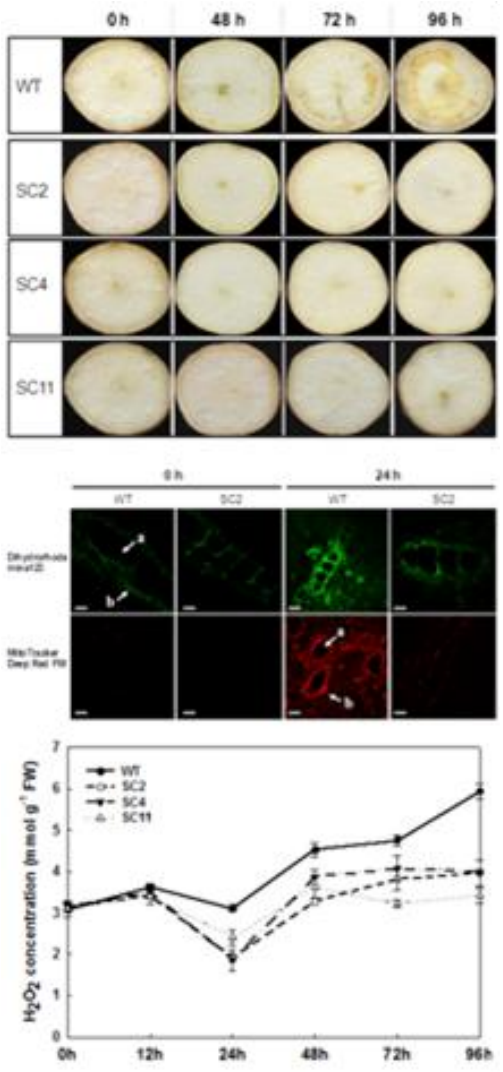
Figure 1. Photographs showing morphology of sever cassava varieties released by Tropical Crops Genetic Resources Institute, Chinese Academy of Tropica Agricultural Sciences. (A) tuberous roots and stems; (B aboveground plant parts.

Technology of Postharvest Loss Reduction

- South China 5 is applied and promoted in more than 200,000 hectares in Pursat Province and Kratie Province in Cambodia.
- The new high-yielding variety of South China 13, suitable for local cultivation, is applied and promoted in PPM Company.

- The local cassava industry in the Republic of Congo: 9.0 tons/ha.
- The new varieties K265 and I93 yielded 42 tons/ha and 26 ton/ha, respectively, and had some resistance to mosaic disease.

Technology of Postharvest Loss Reduction

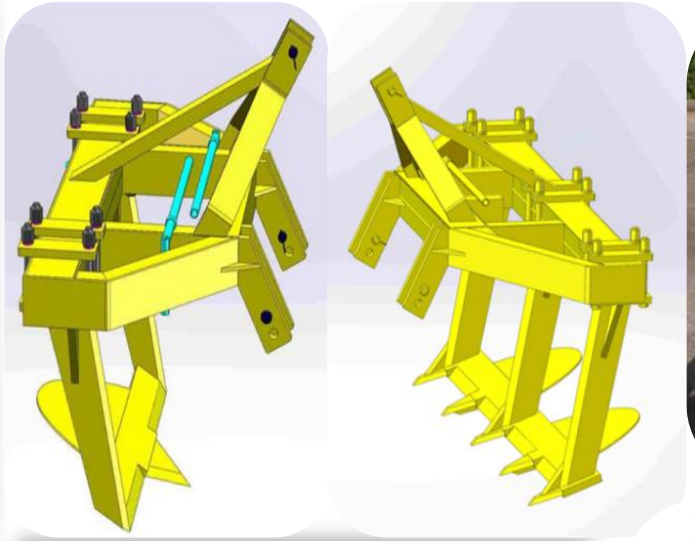


Observation of physiological decay resistance of transgenic RYG-1 (stored at room temperature at an average temperature of 30°C)

Category	Plant Height/cm	Stem Thickness/cm	Number of Cassava	Yield Per Plant/kg	Dry Matter Content	Starch Rate%
RYG-1	108.00	2.00	6.33	2.30	0.42	29.6
SC8	102.33	2.30	5.33	1.73	0.37	29.5

◆ Using a genetic transformation system, *AtGlo*S2 was transferred into the South China 8 variety, which significantly improved the postharvest physiological rot tolerance of South China 8.

Technology of Postharvest Loss Reduction



Digging/Pulling with Hoes

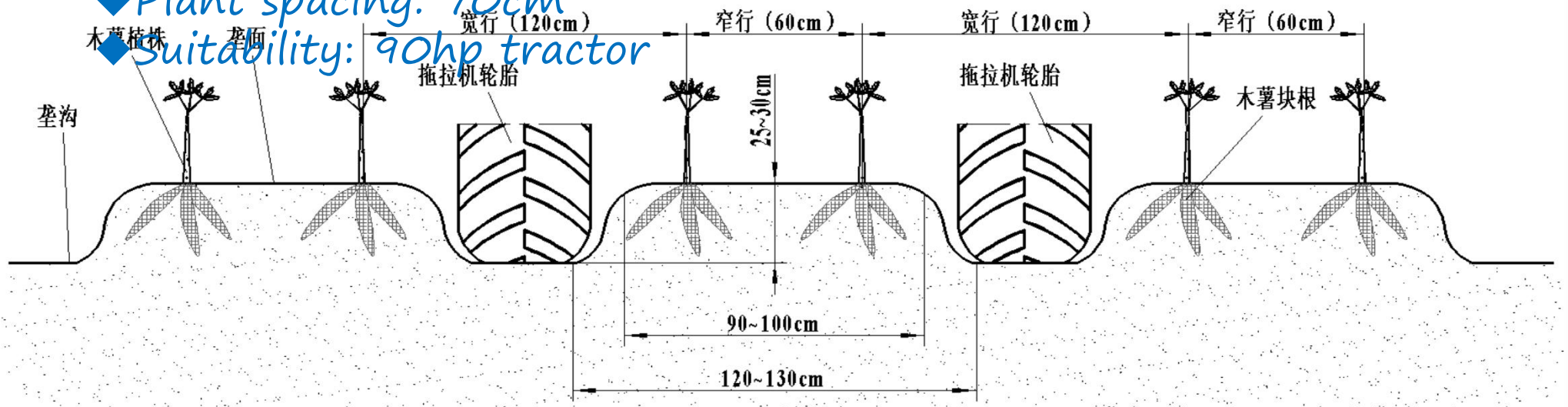
Mechanical Plow

Mechanical Rake

Technologies of Postharvest Loss Reduction

Mechanized Planting Technology

- ◆Inter-monopoly width: 120cm for wide rows and 60cm for narrow rows
- ◆Monopoly width: 60cm
- ◆Plant spacing: 70cm
- ◆Suitability: 90hp tractor



Technology of Postharvest Loss Reduction

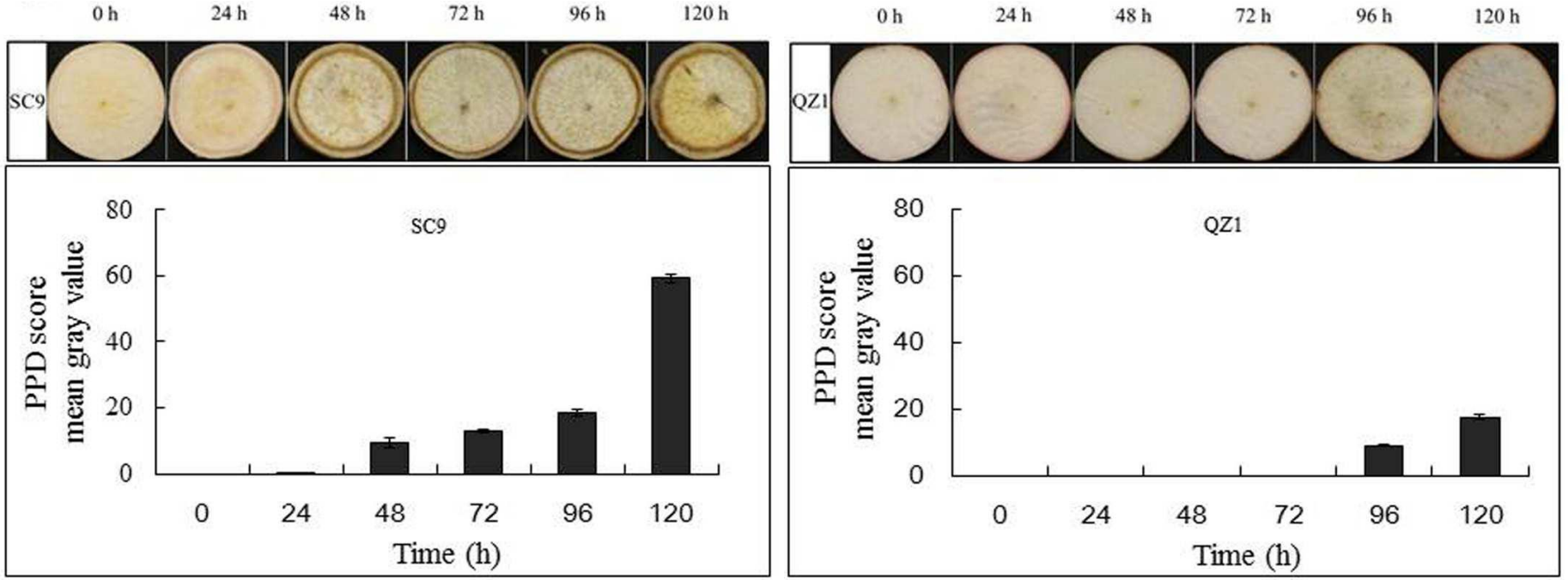
Mechanized Harvesting Technology

- Harrow width: 120cm
- Suitability: 90hp tractor

Technology of Postharvest Loss Reduction
(Freshness Preservation Technology)

◆ Postharvest Physiological Deterioration

Post-harvest Physiological Deterioration (PPD) refers to the physiological phenomenon of cassava root tubers appearing inside and outside the central column about 3 days after harvesting, and the black spot will be irreversible changes with storage time and storage environment, closely related to the variety, external conditions.

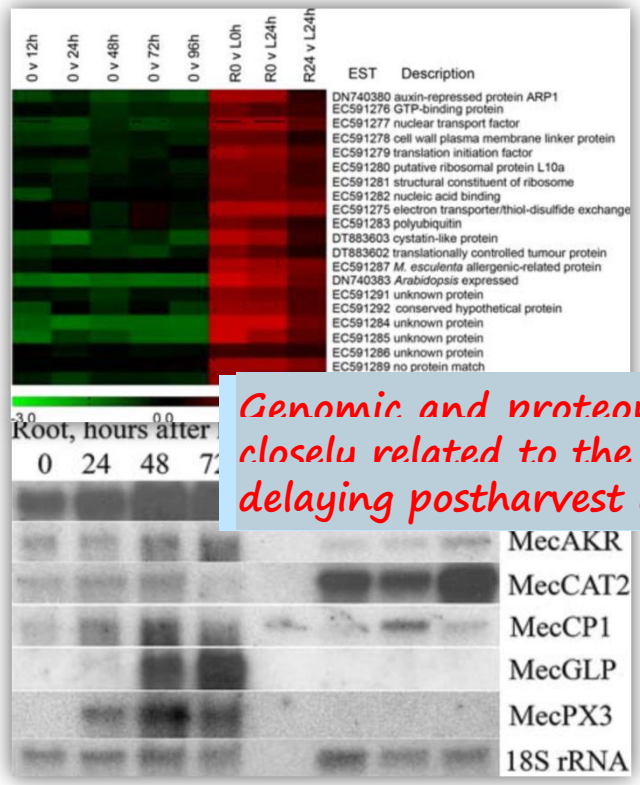


It is reported that global postharvest losses of fresh cassavas are about 15% of production. Post-harvest preservation is an important measure to reduce post-harvest losses of fresh cassavas, especially in tropical cassava production areas with high temperatures and high humidity, and preservation technology is particularly important.

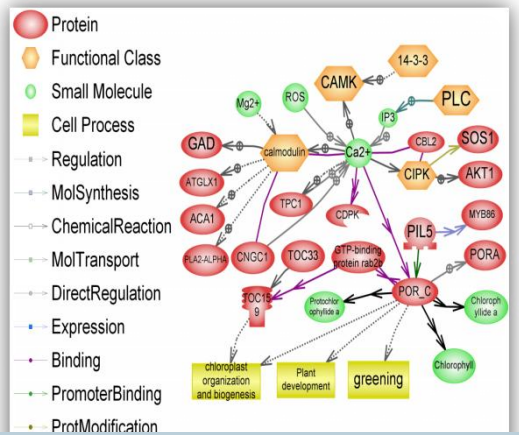
Technology of Postharvest Loss Reduction

(Freshness Preservation Technology)

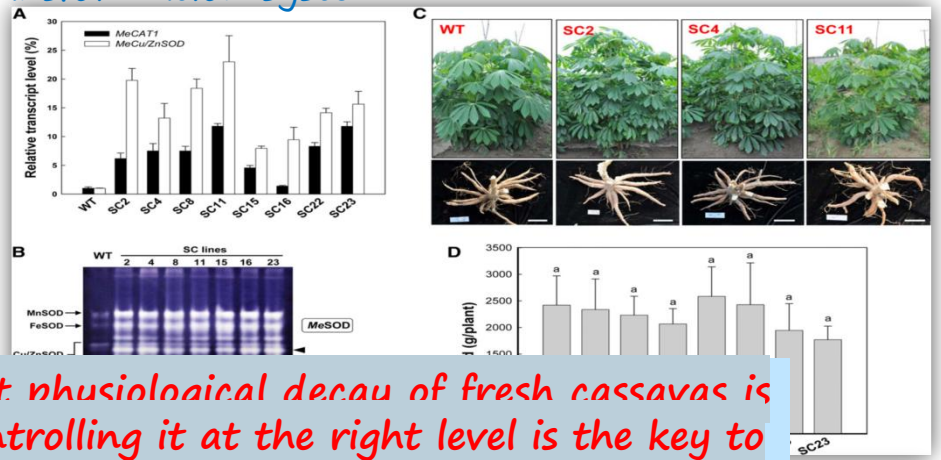
- Post-harvest physiological



- In 2003, Professor John Beching, found that the tuber storage process was significantly upregulated with the expression of seven genes associated with reactive oxygen species scavenging.

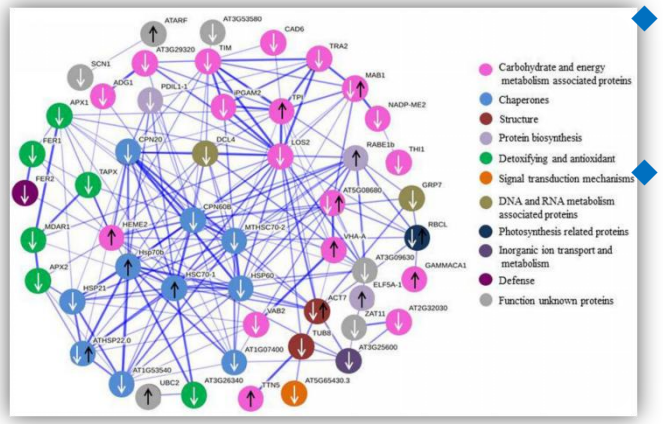


- In 2013, researcher Peng Zhang successfully demonstrated that Cu/Zn SOD enzymes are closely related to the scavenging of reactive oxygen species during storage of cassava tubers using a genetic transformation system.

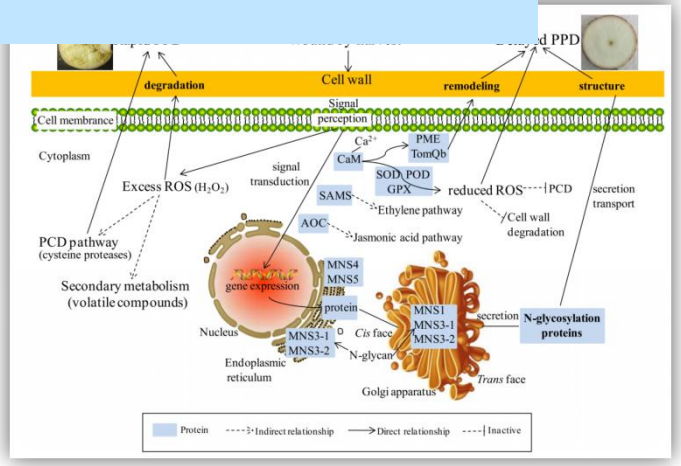


Genomic and proteomic studies have shown that postharvest physiological decay of fresh cassavas is closely related to the imbalance of reactive oxygen species, controlling it at the right level is the key to delaying postharvest decay.

metabolism of tuberous roots.



- In 2017, Yu-Ling Qin proposed the PPI regulatory network.
- In 2019, Fei-Fei An proposed a regulatory network consisting of 7 genes in the Golgi apparatus.



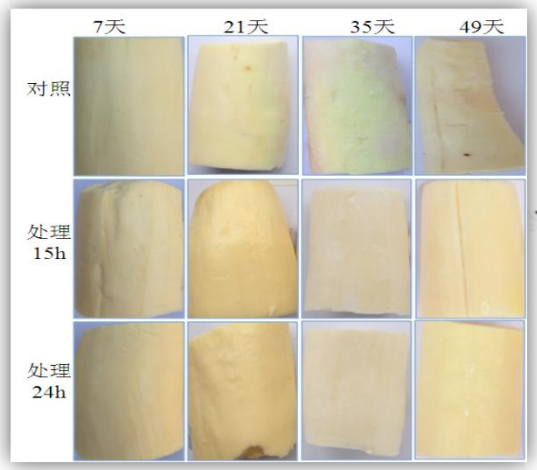
Technology of Postharvest Loss Reduction
(Freshness Preservation Technology)

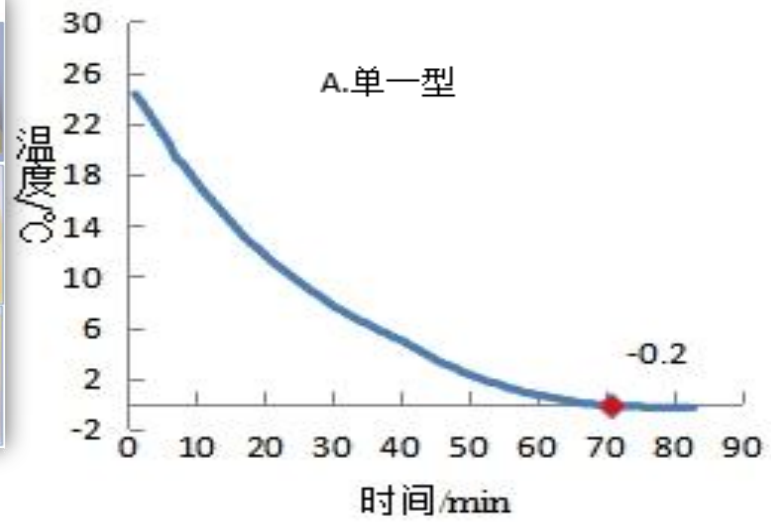
◆ Technologies of Postharvest Loss Reduction

（1） Physical preservation technology: Film Coating + Low Temperature Preservation

◆ Fresh cassavas coated with edible fruit wax can be stored at a low temperature of 4°C for about 15 days.

Technology of Postharvest Loss Reduction
(Freshness Preservation Technology)

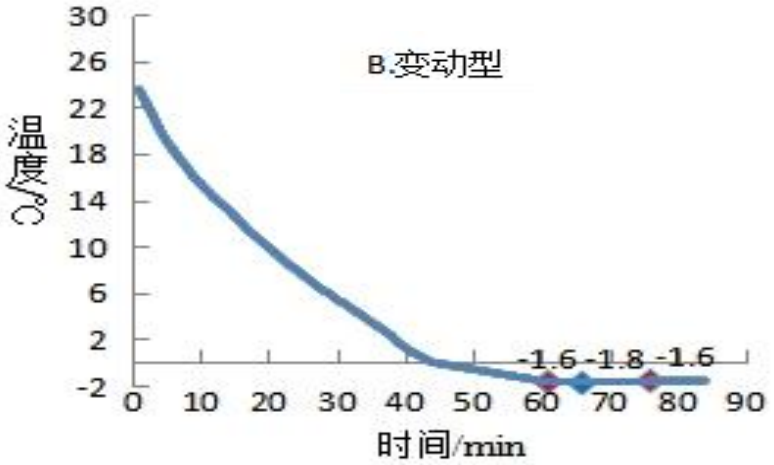




◆ Technologies of Postharvest Loss Reduction

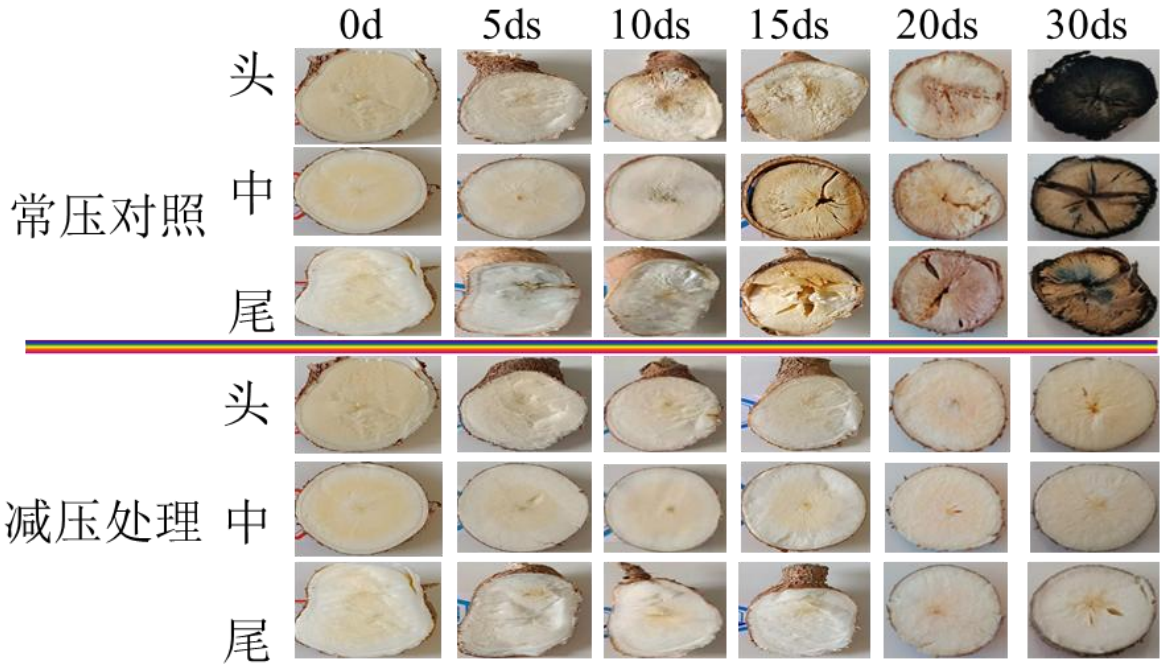
（1） Physical Preservation Technology: Freezing Point Pre-cooling + Low Temperature Preservation

◆ Cassavas treated with freezing point pre-cooling can be stored and kept fresh at low temperature for about 25 days.



Technology of Postharvest Loss Reduction

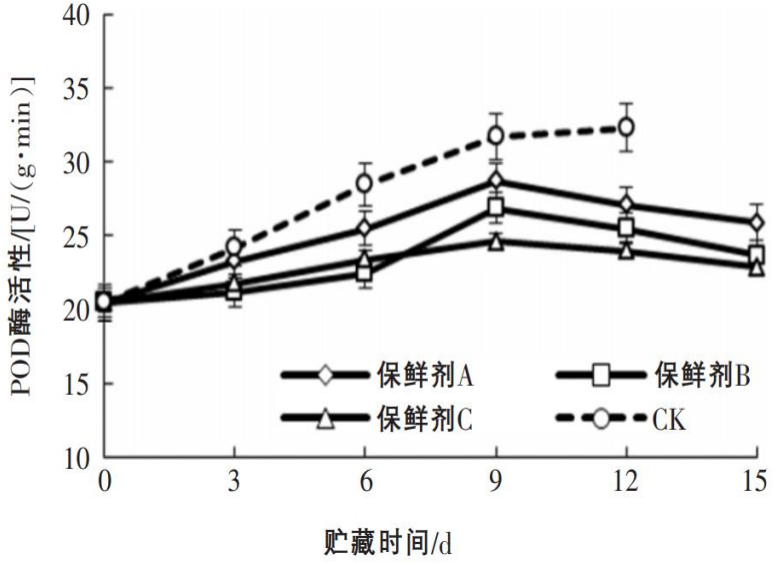
Physical Preservation Technology: Reduced Pressure Preservation

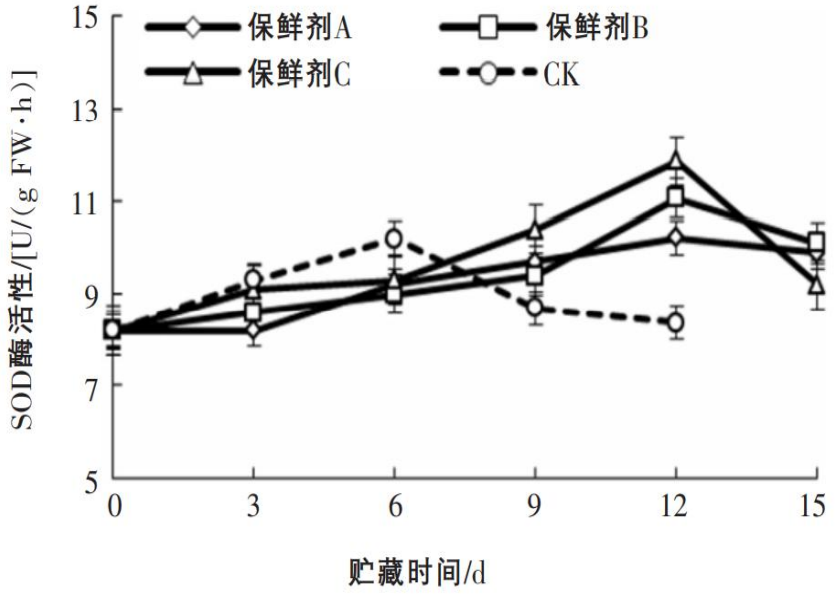


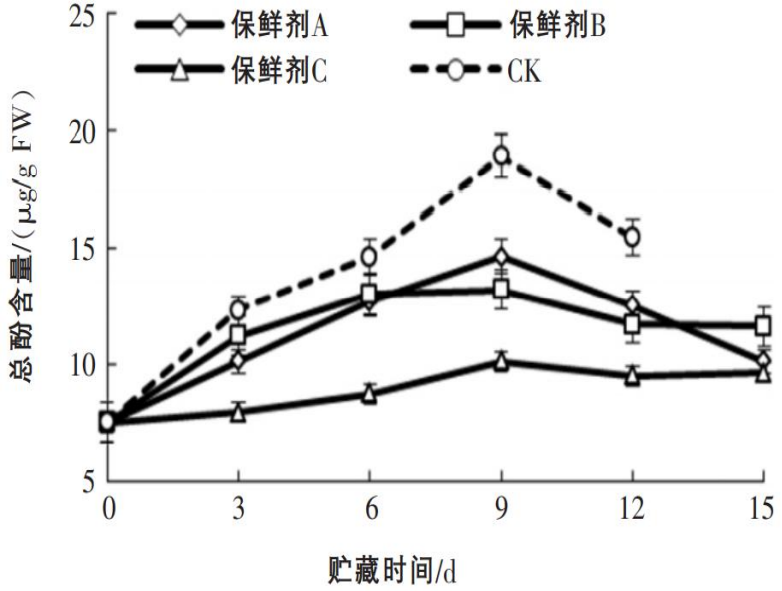
- By pre-cooling treatment, fresh cassavas start to experience postharvest physiological deterioration only after 30 days of storage at room temperature under 0.03-0.05 MPa. If stored at low temperature, it can be extended for more than 60 days

Technology of Postharvest Loss Reduction

(2) Chemical preservation technology: using 1.5% chitosan + 0.15% citric acid + 0.25% calcium chloride solution for 10min can improve the ROS scavenging ability of fresh potatos, so as to effectively prolong the post-harvest storage period of fresh potato and delay the occurrence of PPD.



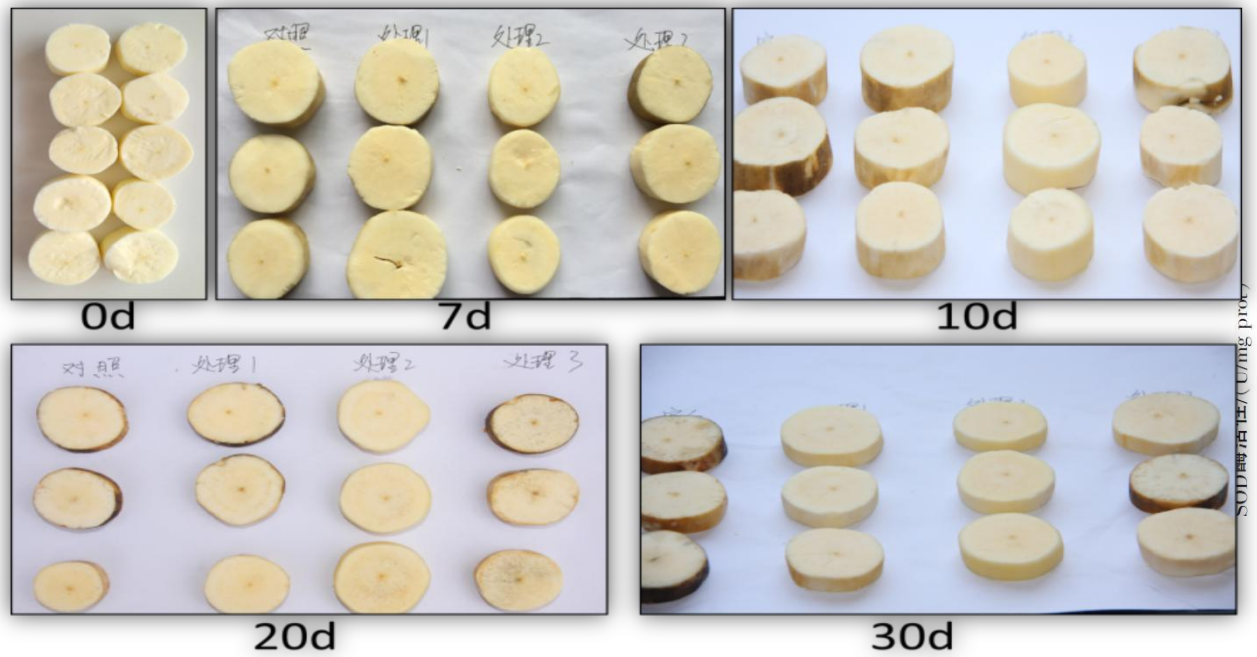


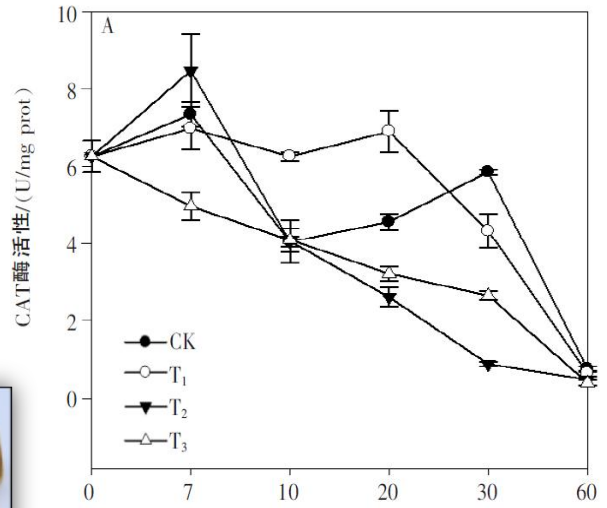


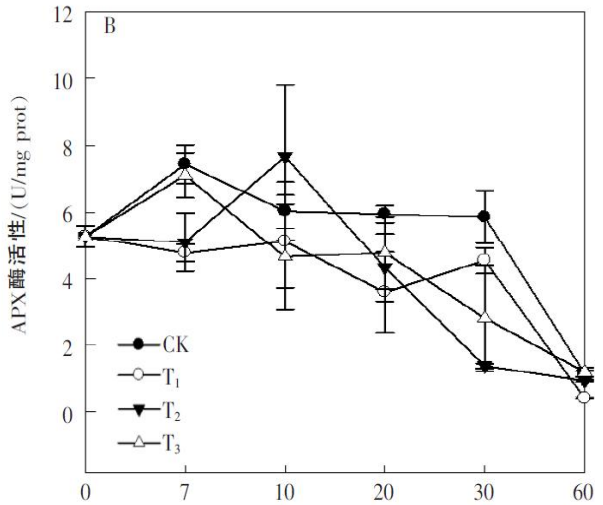
Technology of Postharvest Loss Reduction

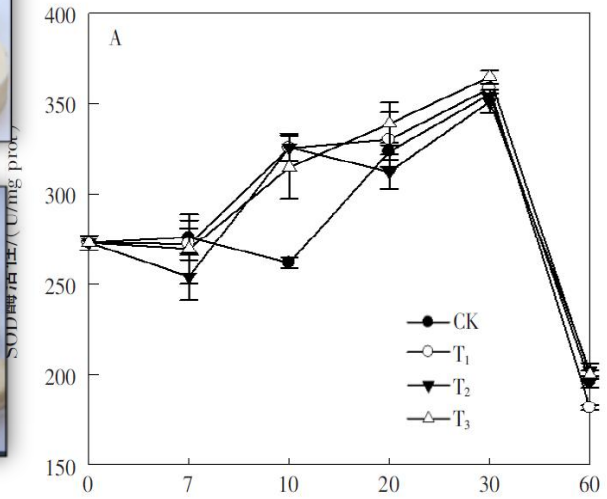
(Freshness Preservation Technology)

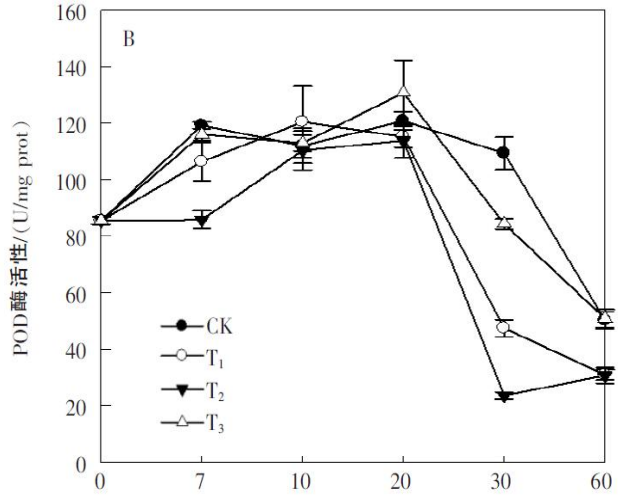
Chemical preservation technology: fresh potatoes can be stored for 20 days after being treated at 98 ℃ with 10 g / lnacl hot water + antioxidant 3% Na2S2O5 solution for 2 minutes to delay the occurrence of PPD











Technology of Postharvest Loss Reduction

◆ Storage comparison

Fruit wax coating / low temperature preservation technology

Advantages: The storage effect is good. There is no browning and no obvious change in hardness within 15 days.

Disadvantages:

1. The operation is cumbersome, and the labor cost is high;
2. There are potential food safety hazards;
3. The injured potato is not suitable, and the selectivity of raw

Freezing point cold preservation

Advantages: easy to operate, easy to industrialized treatment and high benefit; The supply and marketing chain is sound.

Disadvantages:

1. flavor slightly changes,
2. Low temperature storage, high energy consumption;
3. After peeling and low-temperature storage, the root tubers lost water and shrunk, and their appearance was not good.

Low pressure refrigerated preservation

Advantages: Suitable for industrial application; Fresh potato has the best storage effect.

Disadvantages:

1. High standard for storage facilities;
2. After low-pressure storage, the shelf life at room temperature is only 7 days;
3. It is not suitable for low

03

Technology of Processing

Processing Technology

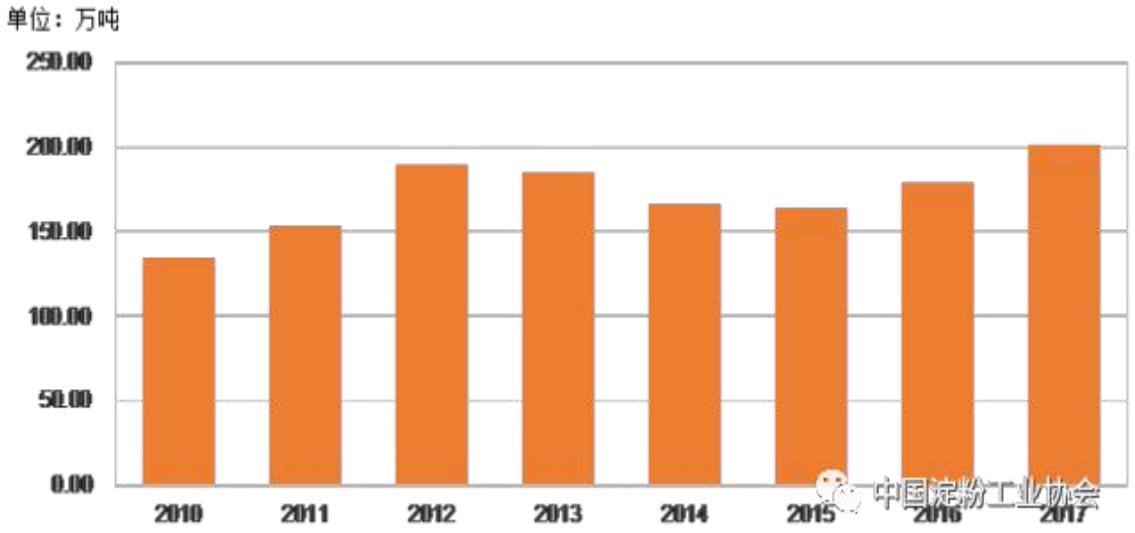
◆ Starch Processing

■ Cassava is mainly used for starch processing in southern China. The annual output of cassava starch is about 450,000 tons, mainly distributed in Guangxi. At present, China's cassava starch processing technology has strong independent R & D and design capabilities of processes and equipment

Processing Technology

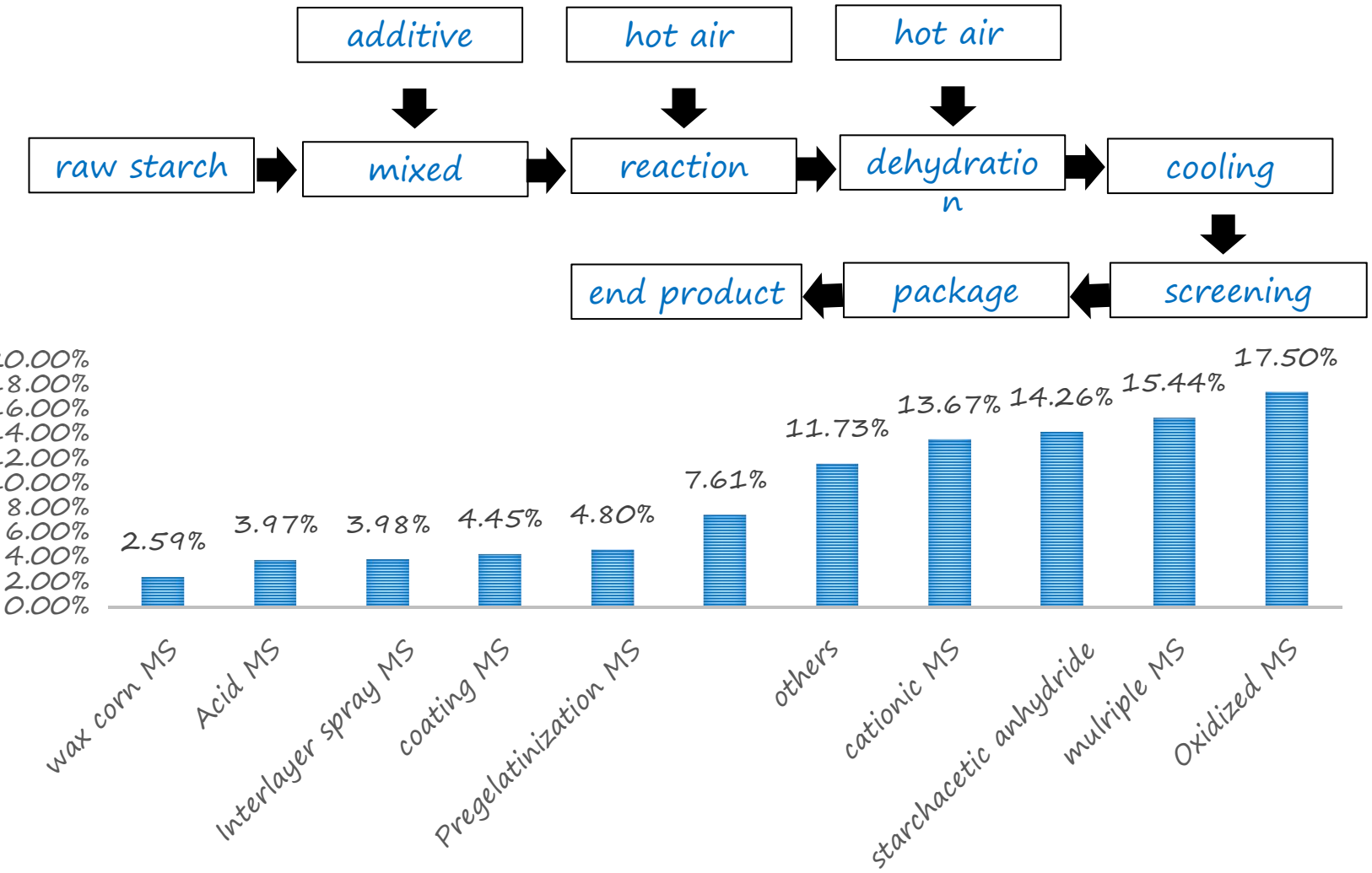
◆ Cassava Modified Starch

Cassava modified starch (CMS) is a kind of starch whose processing characteristics change after physical, chemical or enzyme treatment, including esterified starch, acidic starch, oxidized starch and cross-linked starch.



Processing Technology

◆ Cassava Modified Starch



Processing Technology

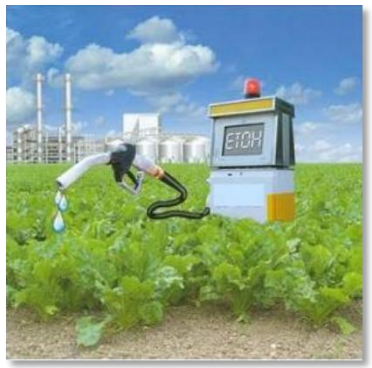
◆Alcohol processing

Main raw materials
* sugar cane
* cassava
* sweet potato
* beet
* sweet sorghu
* corn
* ...

Raw materials	Biological yield t/ha/y	Alcohol conversion rate l/t	Alcohol production l/ha/y
Sugar cane	120	75	9,000
Cassava	30	180	5,400
Sweet potato	60	125	7,500
Beet	80	100	8,000
Sweet sorghum	80	40	3,200
Corn	12	400	4,800

Region	%	Fuel ethanol promotion
Brazil	20	25%
Thailand	10	Bangkok
India	5	Southern Region
Sweden	5	nationwide
Colombia	10	3 major cities
China	10	5 cities




Processing Technology

◆ Alcohol processing

Advantages (1) Easy to plant ; (2)Low cost of raw materials ; (3)High conversion rate ; (4)Low cost of waste disposal

- China's alcohol production has exceeded 2.6 million tons, twice the actual production in 2011.
- China's alcohol production is expected to reach 4.4 million tons by 2025, with huge demand for cassava, sweet potato and corn.

Year	Production capacity (million tons)	☆Capacity （Million tons）
2007	2.80	1.32
2008	2.80	0.86
2009	3.10	1.00
2010	3.15	1.25
2011	3.20	1.30
2017	3.50	2.60
2025	5.00	4.40

Processing Technology

◆Alcohol processing

Comparison of different alcohol processing processes

	Time consuming (hours/batch)	Energy consumption (kWh/ton)	Water consumption (cube/ton)
Traditional Craft	71	210	60
Second Generation Craft	55	150	35
Three generations of crafts	50	120	30
Four generations of crafts	≤48	≤80	≤20

Loss reduction techniques

- Increased efficiency of alcohol conversion
- Cellulose, etc. as the main raw material

Traditional craft

Cassava chips → Crushing → Desanding → Amylase liquefaction → Glycosylase glycation → Yeast fermentation → Filtration / Distillation → Alcohol

Second generation craft

Cassava chips → Crushing → Desanding → Amylase liquefaction → Glycation+ Fermentation synchronization RHIZOZYME™ Yeast → Filtration / Distillation → Alcohol

Three generations of crafts

Cassava chips → Crushing → Desanding → Liquefaction + saccharification + fermentation synchronization STARGEN™+ Yeast → Filtration / Distillation → Alcohol

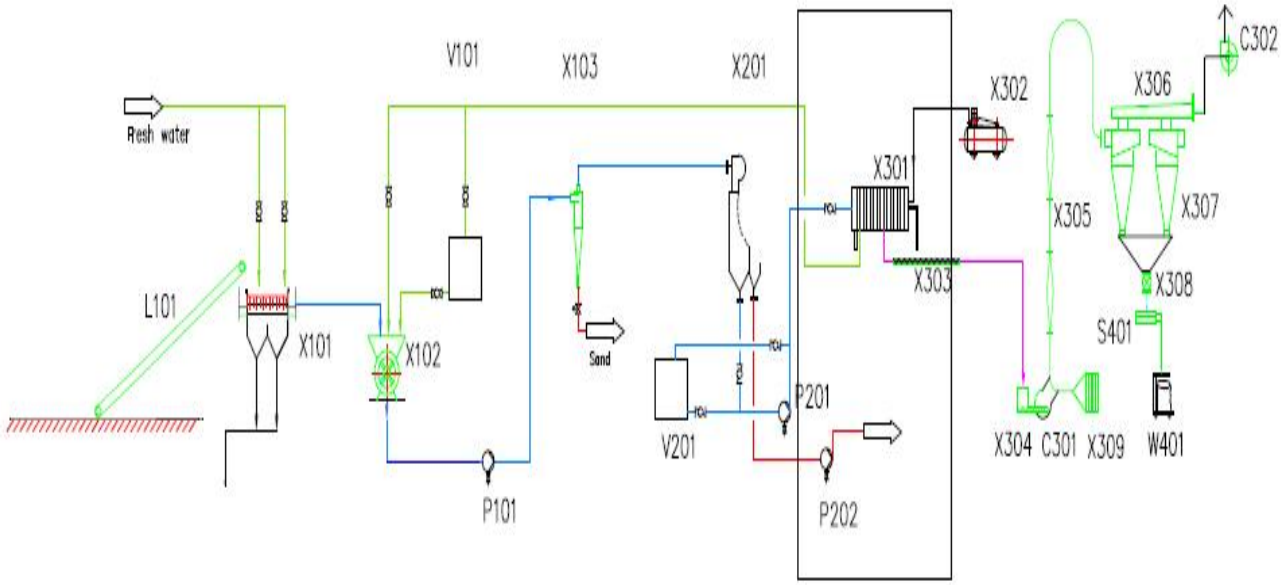
Processing Technology

◆ Cassava powder processing

- Light simplified dry processing and industrialized wet processing.

Dry processing Technology of Cassava Powder

Roadmap of cassava powder wet processing



04

Prospects

Prospect

The use of biotechnology to breed and apply post-harvest rot varieties can greatly reduce the loss of fresh potatoes due to post-harvest physiological decay in the process of transportation and processing, and is also to meet the needs of the current efficient industrial development, and it is also the general trend of low-carbon industrial development.

Prospect

◆ Diversified use of technology is an extension of cassava value chain

The use of cassava flour, stem and leaf and other by-products to develop a series of high value-added products, e.g. cassava flour food, cassava leaf silkworm farming, cassava stem matrix cultivation of black fungus and cassava leaf protein polypeptide products, etc.

面条系列

粉系列

Prospect

- International cooperation is the way out for the sustainable development of cassava industry

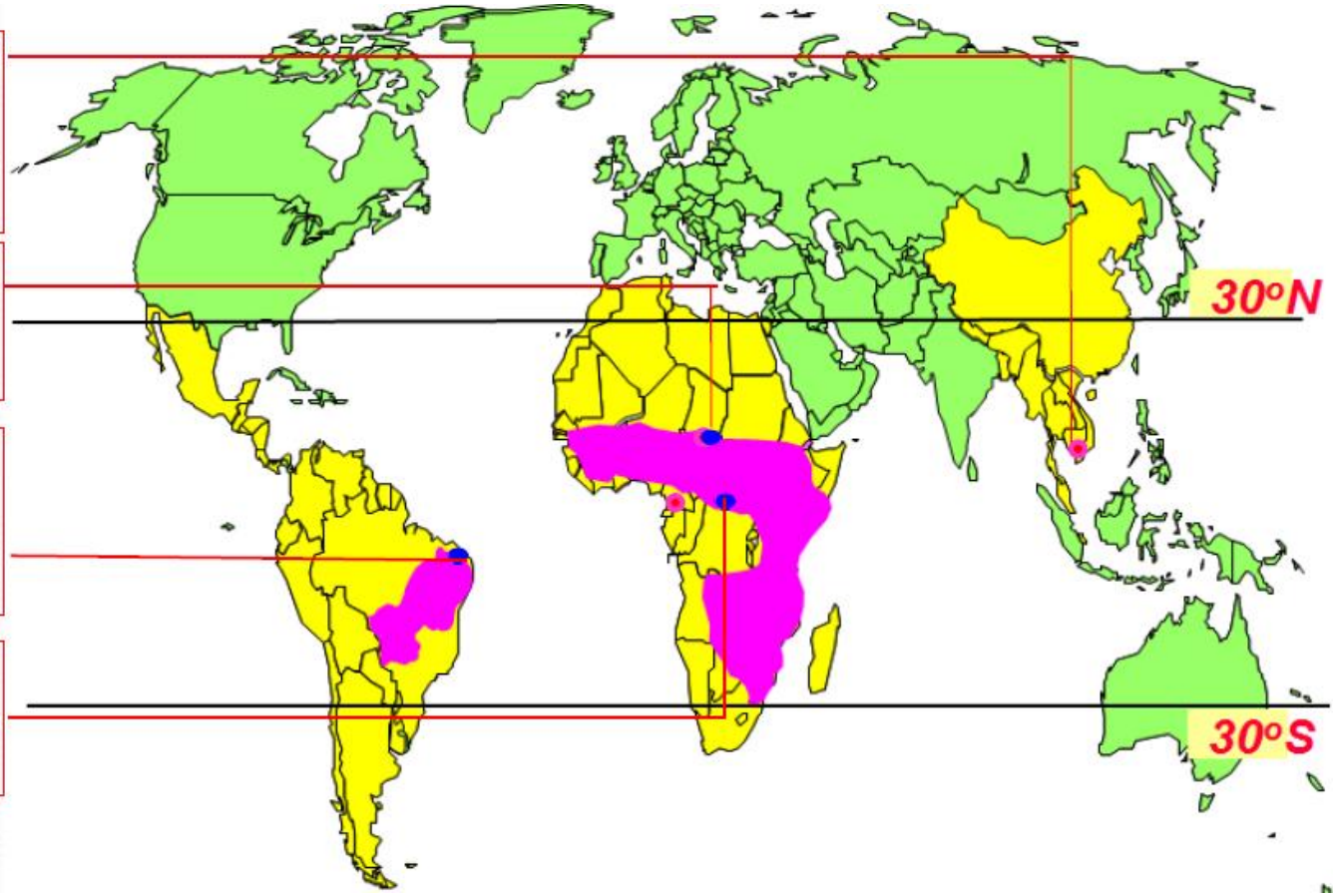
China has cooperated closely with cassava research institutions in Southeast Asia, South America and Africa, successively built 4 international cooperation bases and more than 40 cooperative units

中国--柬埔寨
木薯科技创新中心
China-Cambodia Cassava S&T Innovation center

中国--尼日利亚
木薯中心
China-Nigeria Cassava Center

中国--巴西
蛋白质组学联合实验室
China-Brazil Joint Proteomics Laboratory

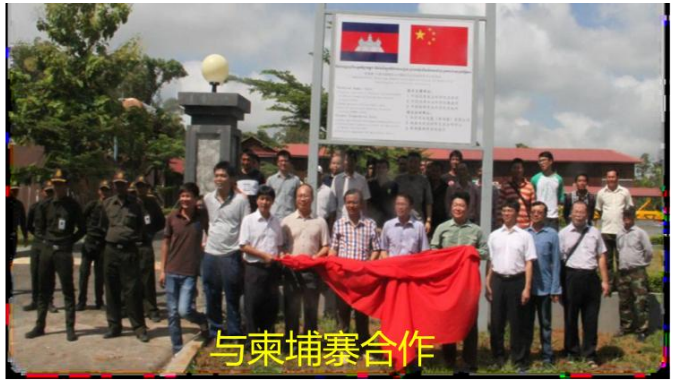
中国--刚果（布）
农业试验站
China-Congo Agro-Exp. Station



Prospects

◆International Cooperation


与IITA合作


与柬埔寨合作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Thank You

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