# especial

Refrigeration | AC & Ventilation | Heat Pumps

### 13.-15.10.2020

# CONNECTING EXPERTS.

NÜRNBERG MESSE

Chillventa eSpecail 2020

# **Technical Progress of Cold Chain Equipment** in China

### **Dr.&Prof.** Changqing Tian

**Technical Institute of Physics and Chemistry Chinese Academy of Sciences, Beijing, China** 

# Outline









# **Perishable food**

Foods apt to deteriorate at room temperature, including: fruits, vegetables, meat, aquatic products, eggs, milk, etc.

### Huge output, hugh losses

- About 1.2 billion ton perishable food output in China in 2019.
- The losses of fruits, veg, meat, and aquatic were reduced from 20%, 30%, 12%, 15% to 11%, 20%, 8%, 10% respectively in last decade.
- Food safety: poor food quality caused by improper storage and transportation, food borne diseases caused by microorganisms and bacteria.

Perishable food output in China (10 <sup>4</sup> ton )*							
Year	Fruits	Veg	Meat	Aquatic			
2015	24525	66425	8750	6211			
2016	24405	67434.	8628	6379			
2017	25242	69193	8654	6445			
2018	25688	70347	8625	6458			
2019	27401	72103	7759	6480			

\*From National Bureau of Statistics of China

### **Refrigerated warehouse capacity in China and world**

Capacity of Refrigerated Warehouses, Twenty Largest Country Markets, Million Cubic Meters.



\* 2018 GCCA Global Cold Storage Capacity Report

Cold Storage Capacity in China (2008-2018)



180 million cubic meters of refrigerated warehouse capacity in China in 2018

The cold chain industry in China has increased rapidly recent years due to excellent policy environment, increasing food quality requirement, and enough economic support.

# **Cold chain industry in 2020**



- "Construction of the First Batch of National Backbone Cold Chain Bases" was issued by National Development and Reform Commission in March, and had approved 17 cold chain bases in July.
- > Cold Chain Logistics Demand Surge Caused by Epidemic: the growth of online fresh food consumption push the increasing requirement of cold chain.
- Beijing-Tianjin Cold Chain Center Project had constructed in May, including three refrigerated warehouses, with a total construction area of 55,000 square meters.
- Cold chain regional development plan in Guangdong-Hong Kong-Macao Greater Bay Area.

# Outline









Stage	Cold processing		Cold storage	<b>Refrigerated</b>	Retail
	Precooling	Freezing			
Eqpt.	Forced air Vacuum Ice Cold water	Forced air(tunnel, spiral, fluidized- bed) Plate	Civil const Assembly CA Stereoscopic	<b>Refrigerated</b> <b>PCM</b> <b>Liquid</b> N <sub>2</sub> /CO <sub>2</sub>	Display cabinet Kitchen refrig
		<b>Immersion</b>			

### **Technical Progress of Cold Chain Equipment in China**

# **Precooling equipment**

### > Precooling with alternating ventilation

### > Precooling with ice slurry

# **Precooling with alternating ventilation**





- With airflow rate of 0.25, 0.5, and 1.0 L s-1 kg-1, the maximum saving time ratios for seven-eighths cooling time are 10.0%, 8.1%, and 7.7%.
- The average absolute deviations of the products temperature can reduce more than 50%, a markedly improvement in cooling uniformity.



### Technical Institute of Physics and Chemistry, CAS



Combining ice slurry and precooling adopting high cooling capacity and heat transfer of ice slurry.



 To solve the problem of insufficient power supply in the field
 To reduce the equipment capacity and initial cost.
 To reduce the operation cost with the low price valley electricity. **Technical Progress of Cold Chain Equipment in China** 

# **Food freezing**

### Ultrasound-assisted freezing

> Magnetic field assisted freezing

# Ultrasound-assisted quick freezing

(IPC)

With the ultrasound, a large number of cavitation bubbles were generated and act as crystal nucleus to induce ice nucleation and improve heat transfer to shorten the freezing time.



Fig. 1 The freezing curves of radish cylinders under different freezing conditions. IF (immersion freezing), IFW (immersion freezing with wrapped treatment), UAIF (ultrasound-assisted immersion freezing), UAIFW (ultrasound-assisted immersion freezing with wrapped treatment)

### Freezing curves of radish

### Compression and expansion of cavitation bubbles UAIFW (ultrasound-assisted immersion freezing with wrapped

# Ultrasound-assisted quick freezing





Total freezing time and phase change time with different freezing methods

Juice loss rate of potato with different freezing methods

SUF

OUF

# Magnetic field assisted freezing

# **Experiment device**



1cooling stage 2 optical microscope 3 CCD camera 4 controller5 nitrogen tank 6 computer 7 alternating current coil8 permanent magnet 9 Gauss meter 10 section sample

- The cooling capacity of the cooling stage is provided by the nitrogen tank, and the cooling rate and the target temperature are set by the controller
- The optical microscope fitted with a CCD camera to transfer the real-time image to the computer

# Magnetic field assisted freezing

### **Experimental results**





The similar size and shape cherries are chosen to cut into small slices (10mm×3mm×0.1mm)

It is clear that the ice crystal area is reduced when the field magnetic field is applied

# Magnetic field assisted freezing

# Microscopic image





### **Control group**

### With alternating magnetic field

The cellular structure remains well when the magnetic field is applied. The ice crystal intracellular and extracellular is homogeneous. The ice crystal area is very small when the alternating magnetic field is applied.

**Technical Progress of Cold Chain Equipment in China** 

# **Cold storage**

### ≻NH<sub>3</sub>/CO<sub>2</sub> refrigeration system

➢ Ground-cooled CO₂ subcritical system

> Combined cooling and heating

# NH<sub>3</sub>/CO<sub>2</sub> refrigeration system





NH<sub>3</sub>/CO<sub>2</sub> cascade system

### NH<sub>3</sub>/CO<sub>2</sub> secondary refrigerant system

# Ground-cooled CO<sub>2</sub> subcritical system





COP=3.2 while evap tem is -23℃.



Cold warehouse (25 thousand tons)

- Less power consumption (0.016 kWh/m<sup>3</sup>·d)
- Enviroment-friendly: natrual refrigerant CO<sub>2</sub>
- > Tend to harmony with nature

### **Combined cooling and heating**



**Technical Progress of Cold Chain Equipment in China** 

# **Retail (last kilometer)**

**Cold cabinet with linear compressor and R290** 

> Multi-modes

# Cold cabinet with linear compressor and R290 🧐



### **Research undergoing:**

- Development of linear compressor with R290;
- Air distribution inside cabinet;
- Development of cold caninet prototype.

### **Qualification:**

- Meet GB/T 21363-2008 design condition, and reach Level 1 energy efficiency
- ➢ ODP=0, GWP<150</p>

Supported by National key R&D project 2016YFD0400905



# Multi-mode: last kilometer of cold chain





**Electrical refrigerated tricycle** 



Fresh food distribution cabinet



**Refrigerated/PCM van** 



Movable self-service convenience store

### **Technical Progress of Cold Chain Equipment in China**

# **Cold Chain & COVID-19**

# **Positive samples of COVID-19 in cold chain**



- ➢In June, Xinfadi Wholesale Market in Beijing, which caused outbreaks of confirmed cases.
- ➢On July 23, detected the new coronavirus in one company in Dalian, which caused o utbreaks of confirmed cases.
- On July 10, Dalian customs and Xiamen Customs had detected the new coronavirus in frozen shrimp container inner wall and outer package samples imported from Ecuador. In July, Pingxiang(Jiangxi province), Chongqing, Yunan, Wuhu(Anhui Province) also detected the new coronavirus in frozen shrimp container from Ecuador.
- ➢ On August 13, a frozen chicken wing surface sample imported from Brazil was found to be positive for NCV nucleic acid in Shenzhen City, Guangdong Province.

▶.....

More than 10 cases of positive samples of COVID-19 in cold chain tested in China.
Virus can survive in a low temperature environment for a long time.

# **Planned solution**



**Cold processing** 

**Cold storage** 

Refrigerated transportation

### Safe&high eff. cold chain combining refrigeration & sterilization

# Sterilization with cold atmospheric plasma



### Cold atmospheric plasma processing prawn



### Sterilization production line with cold atmospheric plasma

### Nano Ag-TiO<sub>2</sub> antibacterial sols



Nano Ag-TiO2 Photocatalytic sols and testing results

- The film of nano aqueous Ag-TiO<sub>2</sub> sols can be cured on all surfaces at room temperature, and the weather resistance is more than half a year.
- Ag ions in the coating can destroy virus protein to form passive protection and kill virus on the surface of substrate.
- TiO2 in the coating can generate reactive oxygen groups under light excitation and kill virus.
- The killing rate of H1N1 coronavirus was 99.9%.

This sols can be used to make Anti-virus packaging materials

# Outline







# Summary



- In China, there are great progress recently in cold chain equipment including precooling, quick-freezing, refrigeration system for cold storage, and last kilometer.
- The quick development of cold chain logistics has promoted the progress of cold chain equipment, which impels strongly the cold chain logistics in return.
- Cold chain equipment in China is still on the stage of developing, there is a large and growing market in the future.

Thank for your attention!

### Changqing TIAN, PhD, Prof.

Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, 29 Zhongguancun East Road, Beijing, 100190, P. R. China Tel: +86-10-82543696 Email: chqtian@mail.ipc.ac.cn http://www.ipc.ac.cn





# Thank you for your attention.

