NARO 農研機構

Research overview of technologies to smartize the whole food value chain to contribute the prevention of food loss

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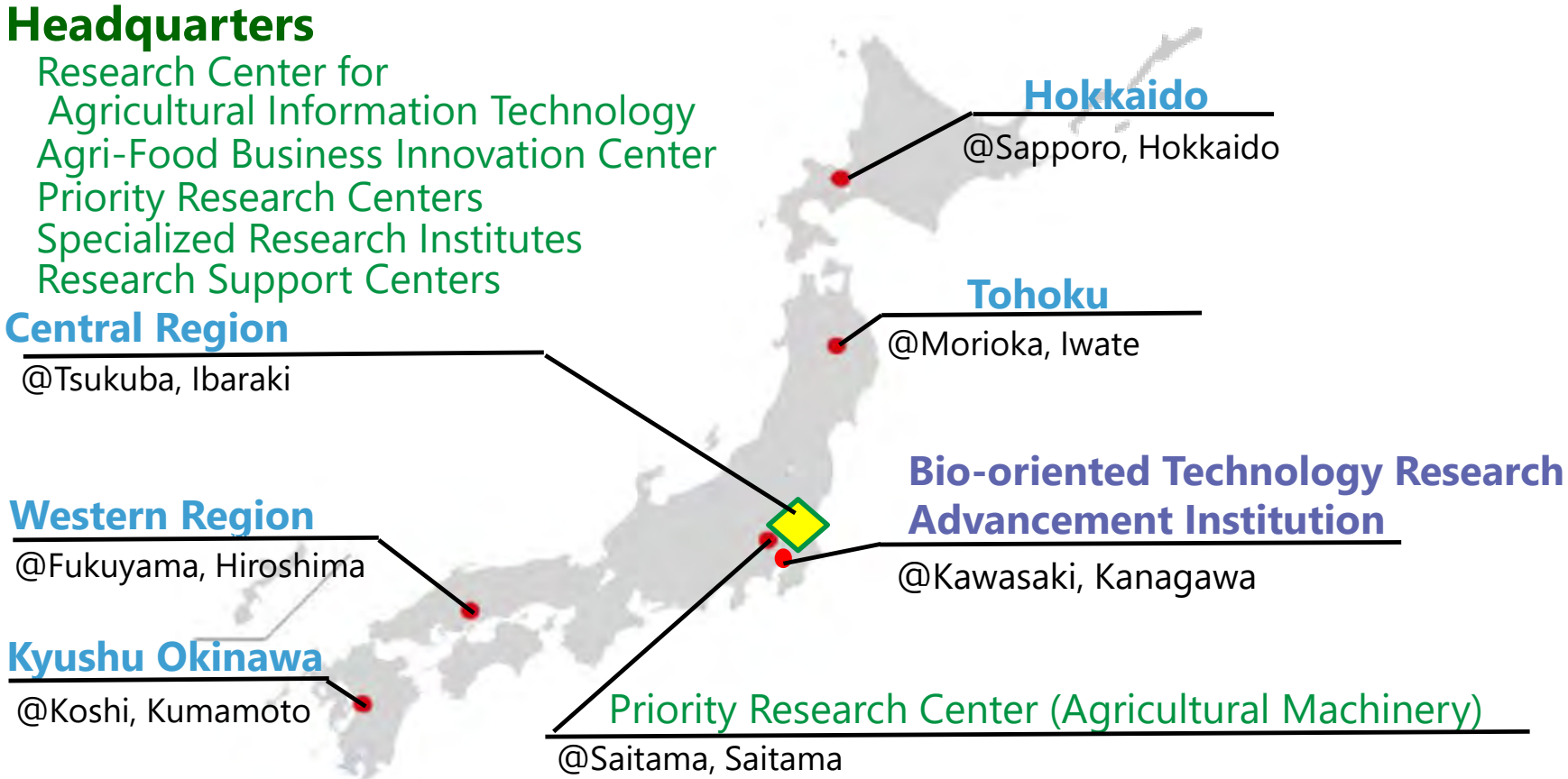
Food Research Institute

National **A**griculture and Food **R**esearch **O**rganization

NARO

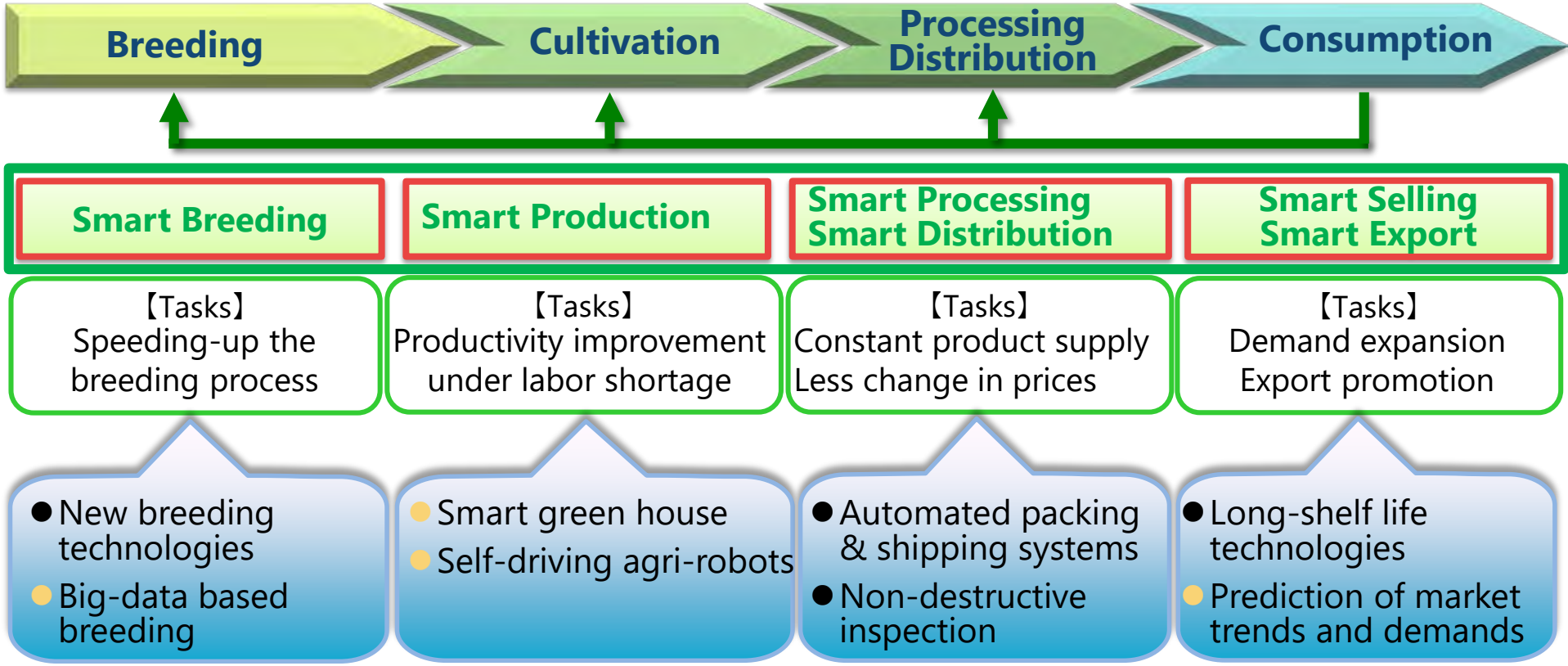
Overview of NARO

- Established in 1893
- Location of Headquarters: Tsukuba, Ibaraki
- Executive Board: 15 members
- 3,338 full-time employees (641 females) including 1,839 researchers (January 2019)
- Annual Budget：91.1B JPY
- Headquarters, 15 Research centers and institutes, 5 Regional Agricultural Research Centers, Funding Agency



Society 5.0 in Agri-Food Industries
-Smart Food Value Chain-

- Data from each process in food value chain are accumulated in the Agricultural Data Collaboration Platform 'WAGRI'.
- The accumulated data are analyzed by AI for optimization of the entire process for productivity improvement, reduction of waste, total cost cut, and technology matching



AI and Agricultural Database Platform ('WAGRI')

Data from each process are collected and analyzed by AI
Analyzed results are fed back to each process

Strategy to realize the Smart Food Value

Smart Breeding

Smart Agri-culture

Smart Distribution and Processing:
Enhancing both Individual Technology Research for Logistics, Processing, Storage, Assessment, Standardization and Information Sharing and their Combination Research

Basic Technologies to Support Smart Food Value Chain:
Secure the Safety and Dependability, Consider the Environment, Maintain the Crops Field and Share, Analyze and Utilize Data

For the realization

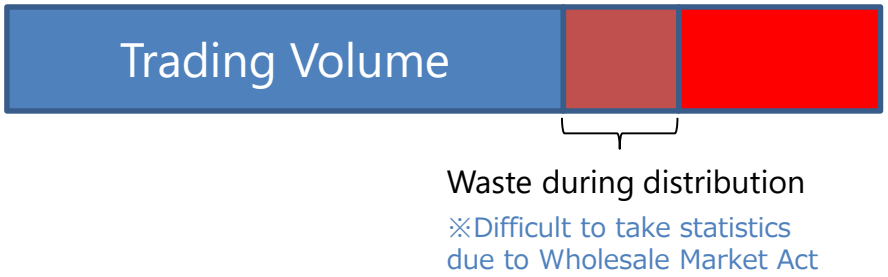
Goal: To realize Smart Food Value Chain as an overall optimum system, not just to develop individual technologies for each process on the food value chain

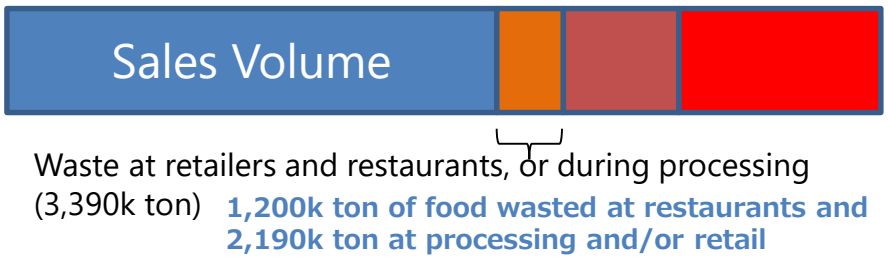
Objective: To improve productivity, eliminate waste, reduce costs, improve quality, needs and seeds matching and optimize the entire food value chain

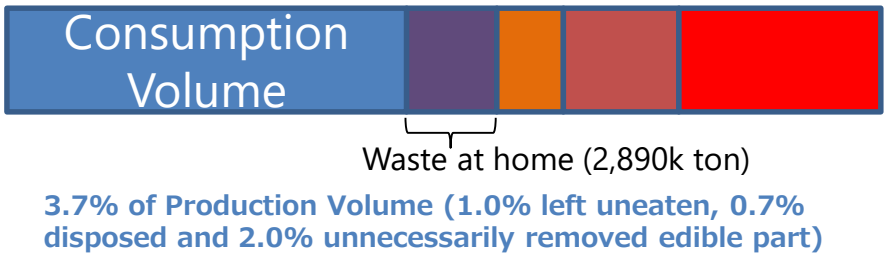
NARO's research areas to focus on: Smart breeding, smart agriculture, smart distribution and processing, AI and ICT, Database establishment

Shunsuke Orikasa, Distribution Economics Institute of Japan (DEIJ)

■Food (Fresh Produce) Waste







<Cause of the Waste>

【Before Dispatch】
- Out of spec to sell
- Too low market price to pay the logistic cost
- Higher yield than ordered in contracts
- No facility to store to postpone the dispatch

【During Distribution】
- Damage during transportation in summer
- No facility to maintain the quality during transportation
- Damage during unloading, loading and stand-by outdoor
- Higher supply by middle traders than demand of customers

【At Retailers & Restaurants, or During Processing】
- Higher stock at retails and restaurants than demand of customers
- Higher stock than processing capacity of machines
- No-show of reservation and/or left uneaten

【At Home】
- Left uncooked
- Lack of cooking ability and/or knowledge
- Left uneaten

※MAFF's statistics on food waste from 2015

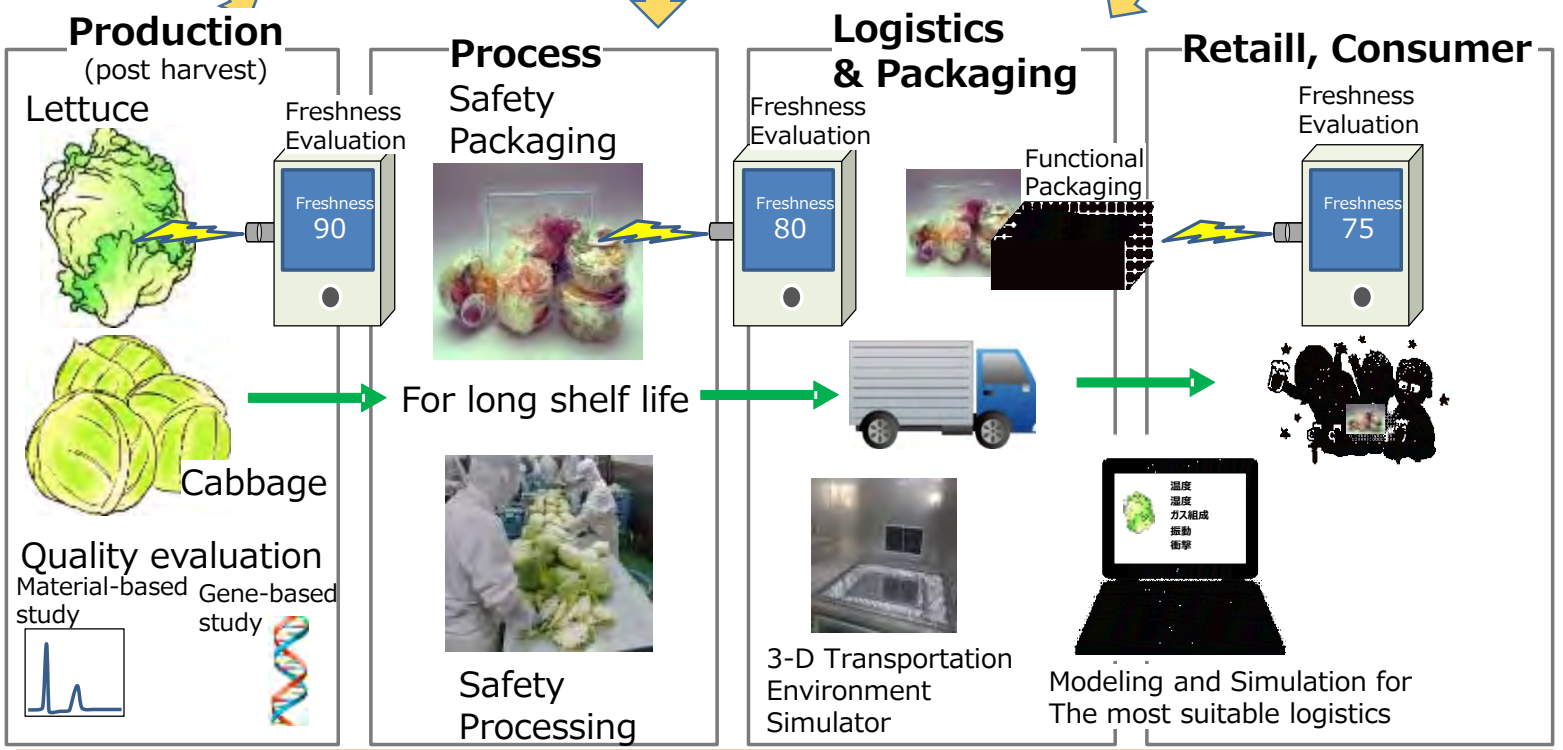
Cross-ministerial Strategic Innovation Promotion Program II (SIP II)

Project Image:
Development of a Smart Food Distribution System by Accurate Quality Evaluation and Quality Control

Development of quality evaluation methods such as **freshness, smell** and so on., using **optical non-destructive measurement technology**, e. g. near- and/or mid-infrared, Raman spectroscopies, *etc*.

Development of **monitoring and simulating system** of the most suitable logistics for each agricultural products **to reduce quality degradation** by measuring acceleration, vibration, temperature, humidity, gas composition, *etc.*

Development of **novel packaging** method such as **controlling inner gas environment, shock,** *etc.* by theoretical method and innovative materials **for long-distance transportation** of each agricultural products both domestic and/or internatonal transportation.



Accumulation of whole quality and quantity data from production to consumer, and **analyze and share** of the information.

Vibration and Shock

Vibration

Continuous oscillations occur about an equilibrium point. ex.) Track bed on driving

Acceleration : Less than 1 G

Shock

A sudden acceleration or deceleration

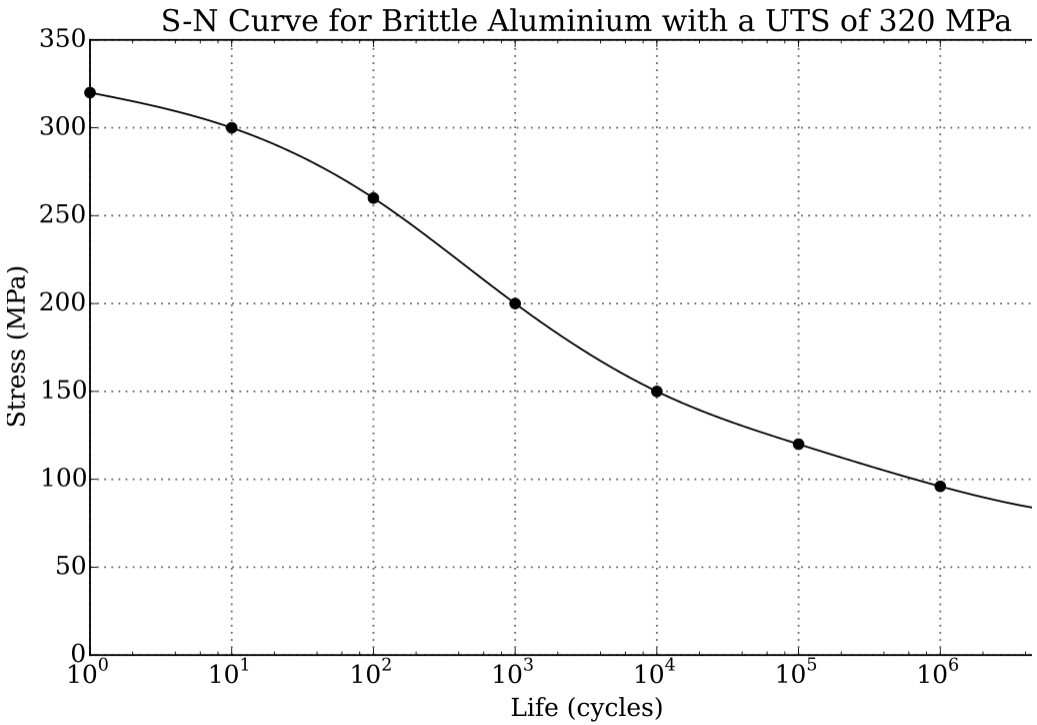
ex.) Handling

Acceleration : Over 10 G

The effect of Vibration and Shock on fruit damage should be considered separately

Vibration Damage

Metal fatigue can be described by “S-N curves”



https://en.wikipedia.org/wiki/Fatigue_(material)

https://ja.m.wikipedia.org/wiki/:Crankshaft_fatigue.jpg

S-N curves is the relationships between Stress and Cycles in terms of damage to objec

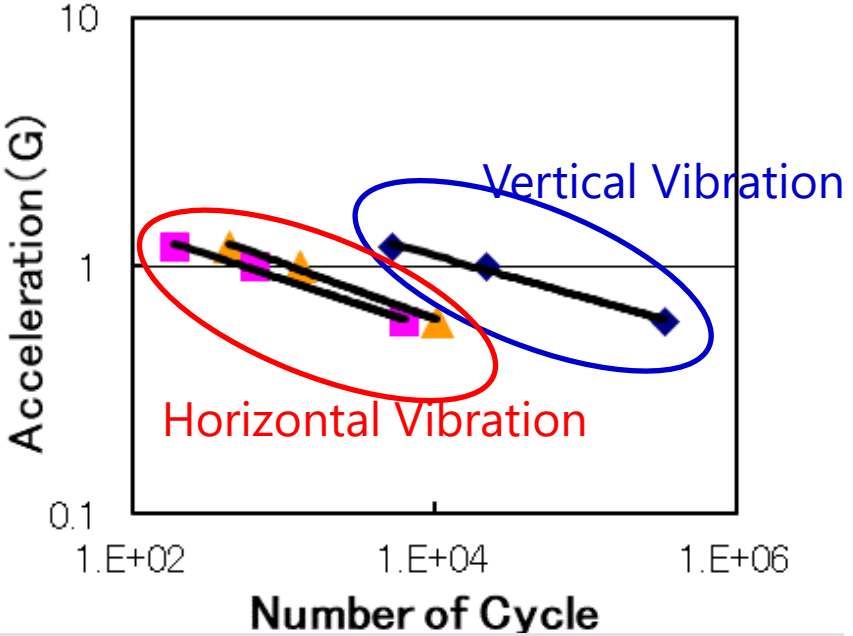
Early study demonstrated that S-N curves can be applied to fresh produce (Iwamoto, 1980).

Vibration Damage

S-N Curves of fresh produce

3 Dimensional vibration simulator

Usual strawberry package in Japan

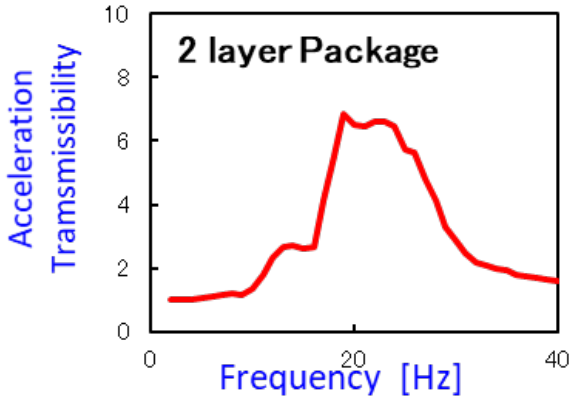


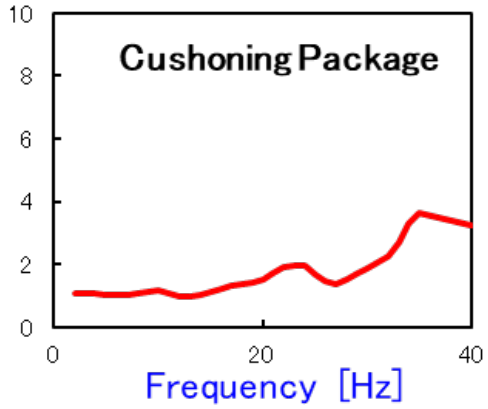
- Damage characteristics were described with S-N curves
- Damage will occur easily with horizontal vibration
- By using this method, we can predict the limit of transportation distance.

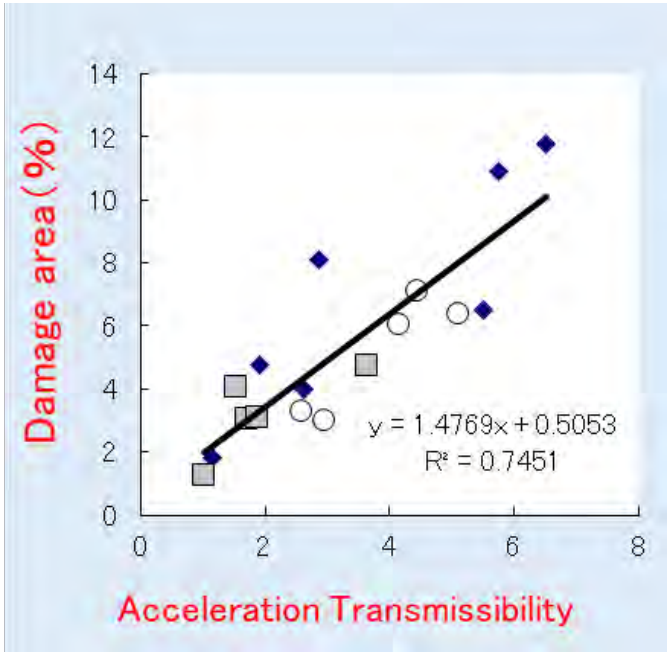
Nakamura et al., Effects of Vibration Frequency and Direction on Damage of Strawberries, The society of agricultural structures, Japan, 38(2), 101-108, 2007

Vibration Damage

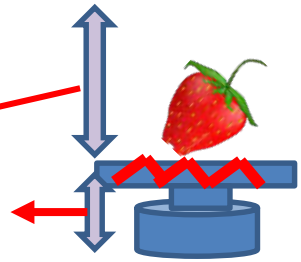
Package evaluation using acceleration transmissibility







$$\text{Acceleration Transmissibility} = \frac{\text{Acc. of Fruit}}{\text{Acc. of Vibration table}}$$

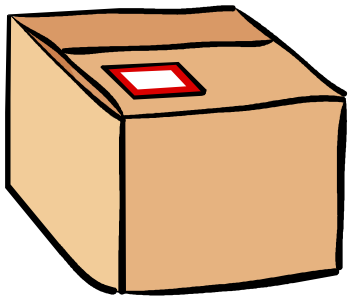


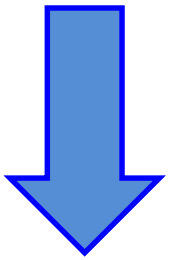
- Acceleration Transmissibility can be used as an index of cushioning characteristics for perishable fruits.

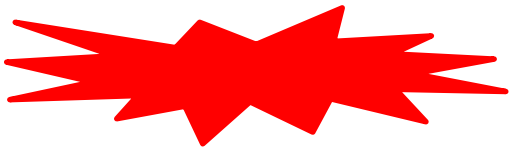
Nakamura, et al, Effects of Vibration Frequency and Direction on Damage of Strawberries, The society of agricultural structures, Japan, 38(2), 101-108, 2007

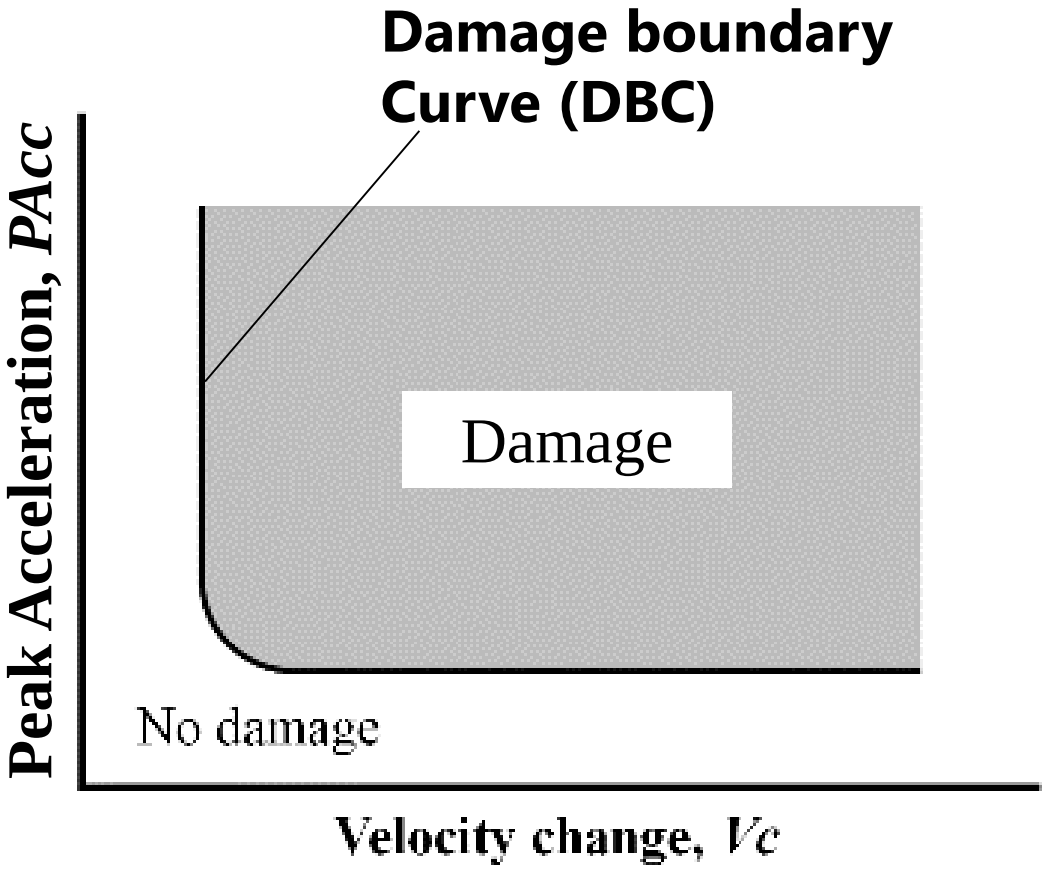
Shock Damage

Damage Boundary Curve (DBC) Theory









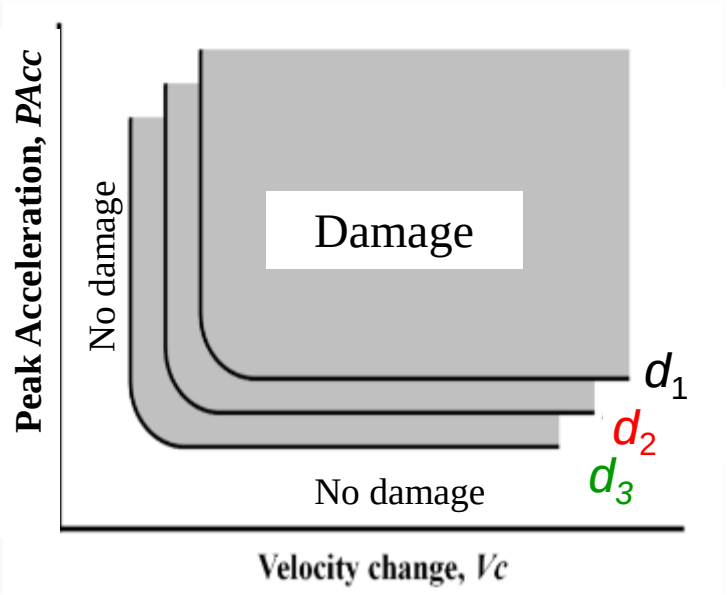
DBC theory・・・Lose commercial value by 1 shock

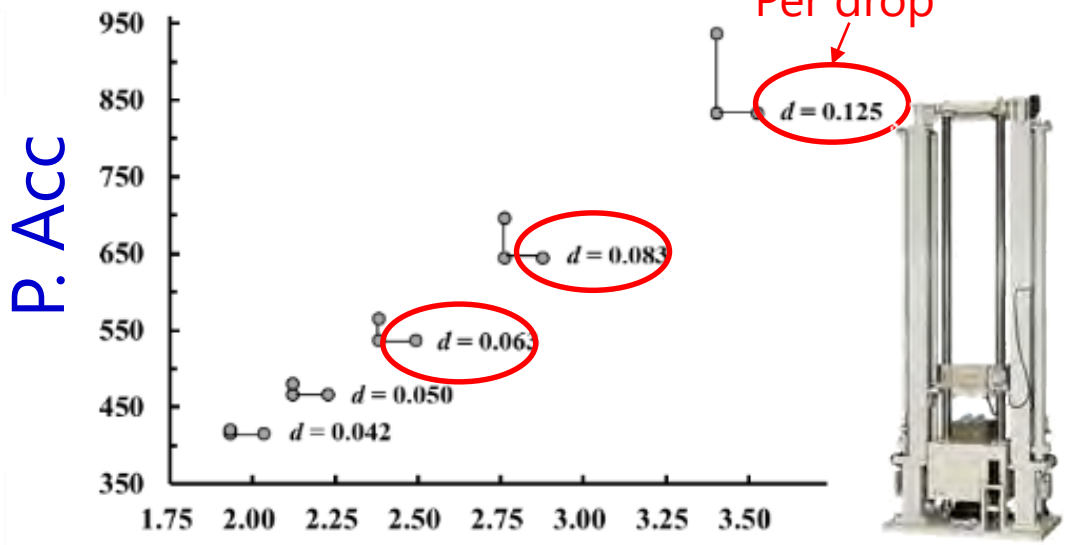
Fruits are considered to lose value by several shocks

Shock Damage

Extended DBC Theory for fresh produce

The change in the degree of damage per shock (*d*) to strawberries subjected to repetitive shock depends on the combination of change in velocity (*Vc*) and peak acceleration (*PAcc*).





$$\text{total fatigue} = \sum d$$

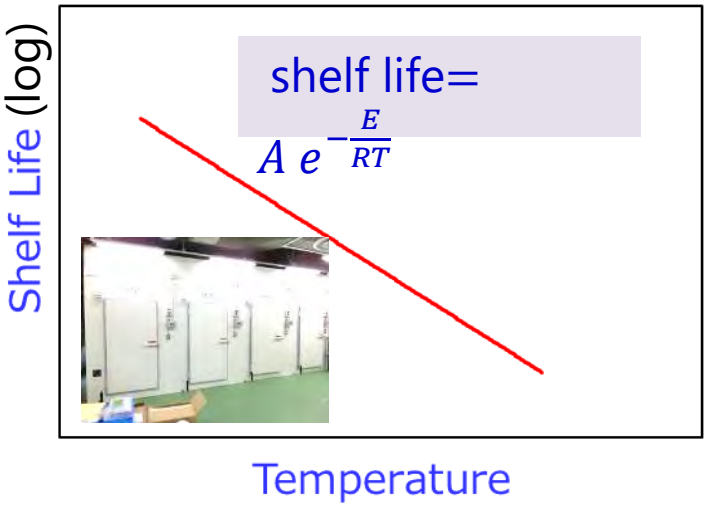
Lose commercial value
When "total fatigue > 1"

(Kitazawa *et al.*, *IAPRI Symposium 2013*).

Prediction of Quality Change

Current Model

Ex.) Time Temperature Tolerance (TTT)

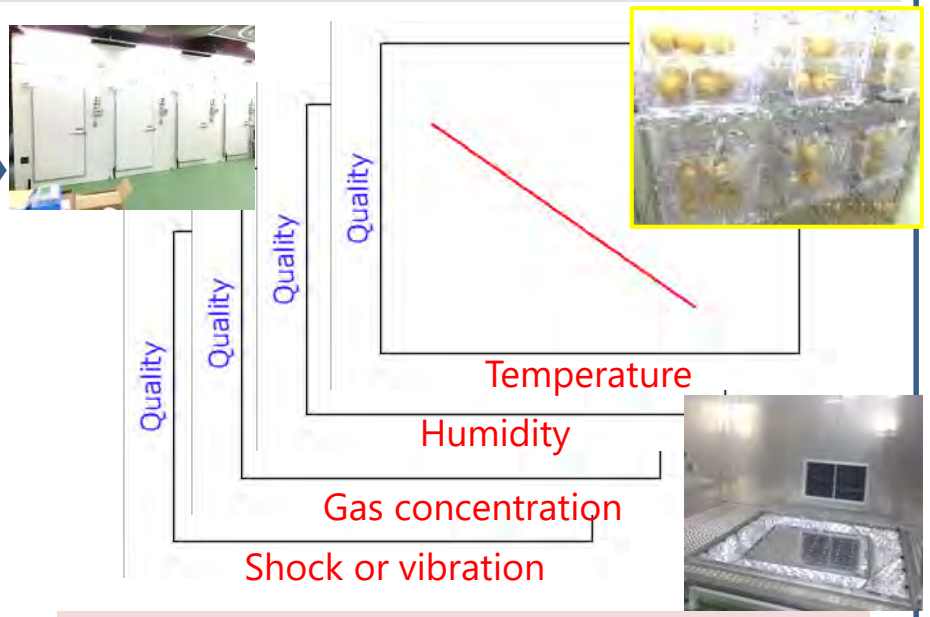


- Known as relationships between Shelf-life and Temperature
- Used for Processed food, Frozen food, and a part of fresh produce
- Temperature is the most important distribution factor, but not the only

Future Model

Time Environment Tolerance (TET)

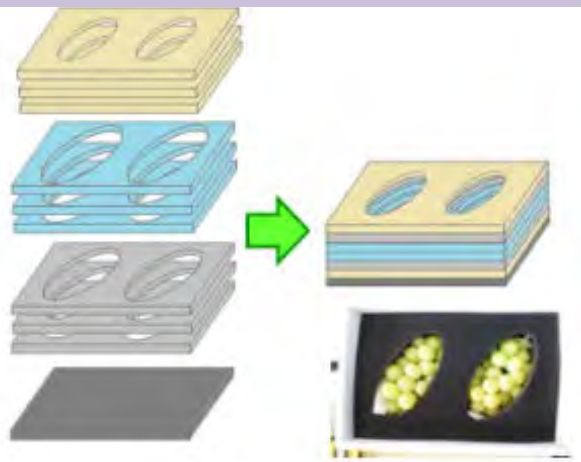
$$Quality = F(Time, Temp, Hum, Gas, Acc, etc..)$$



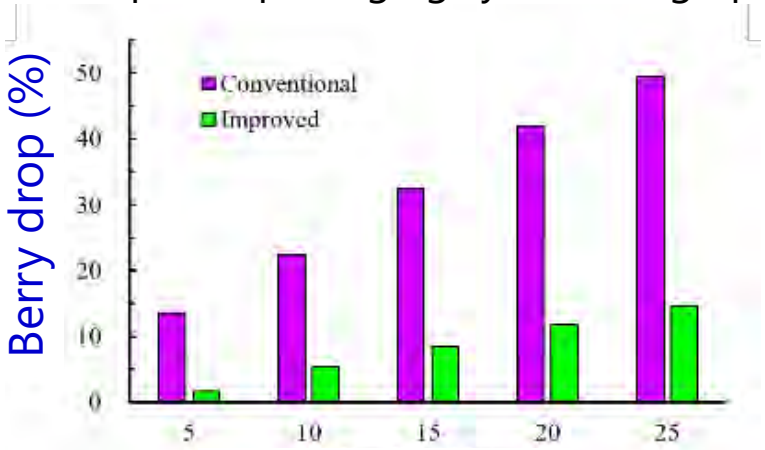
- To control the food quality or food loss, a new prediction model is needed using various distribution parameters

Ongoing researches...

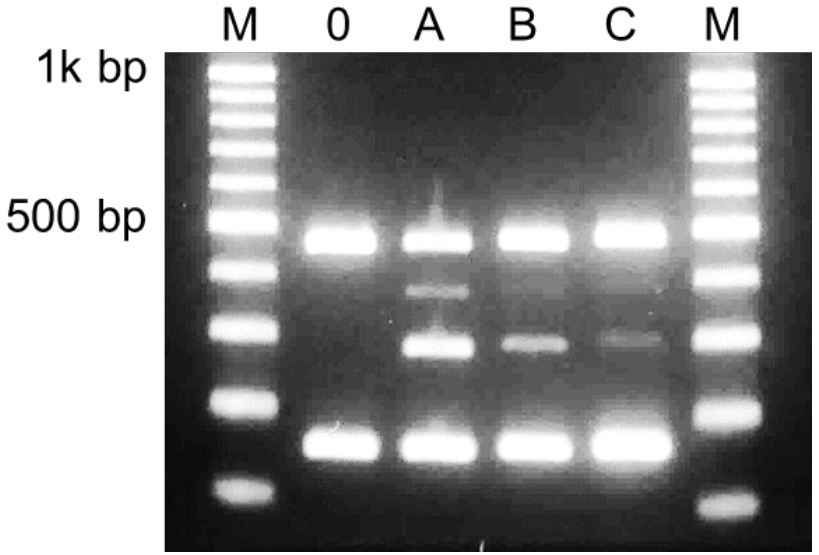
Develop New Cushioning Package



Proposed packaging system for grape



Detection of freshness change



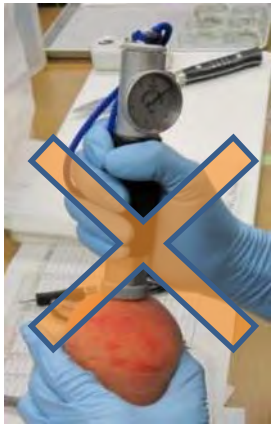
Gene Expression Method for Evaluating Freshness before discoloration

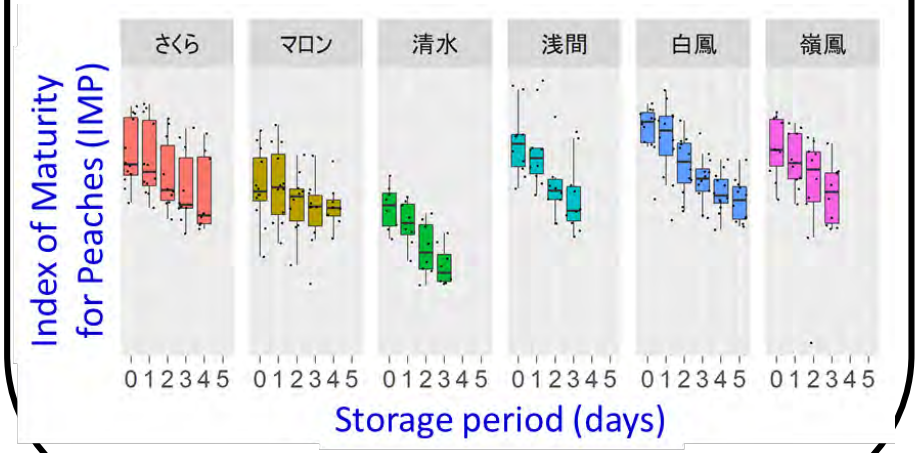
*H. Kitazawa, (2017). Design Registration in Japan, No. 1572040.

Nagata, et al, (2016) Food preservation science 42(6), 247-253,

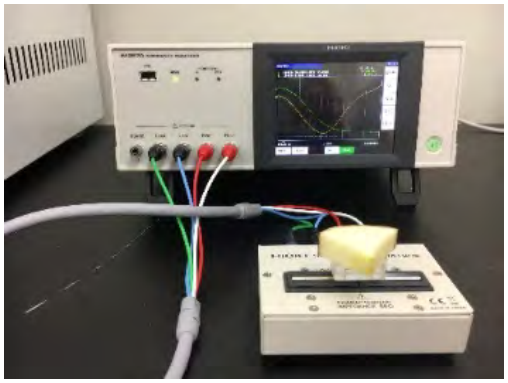
Ongoing researches...

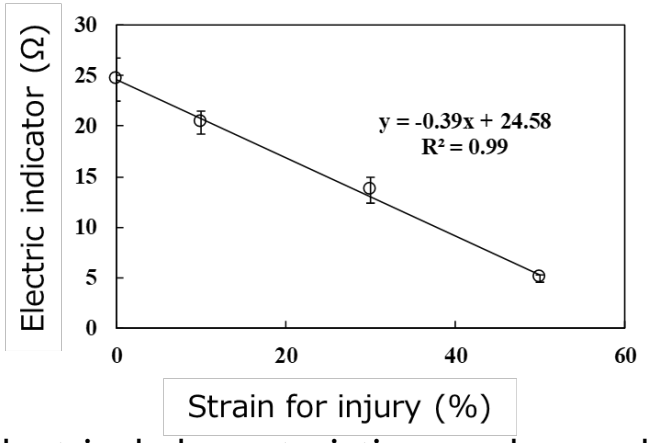
Non-destructive measurement of firmness (ripeness)





Application of electrical characteristics on quality evaluation of fresh produce





Electrical characteristics can be applied to quantify physical and physiological quality changes.

Y. Uwadaira *et al.*, 2018 VIS-NIR spectroscopy *Heliyon*, **4**, e00531

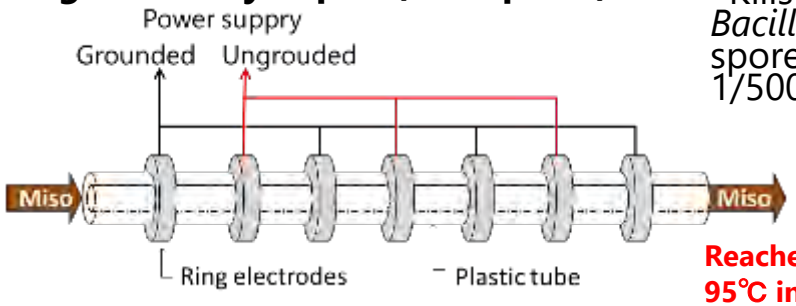
Watanabe et al, 2018 Food and Bioprocess Technology, 11, 2125-2129

Smart Processing - Minimum Heating Process Technology-

- Minimum heating process (MHP) technology allows to sterilize foods by electric power in short time.
- MHP keeps fresh taste, texture, flavor, color and nutrition of foods.
- MHP contributes to food safety and longer shelf life.
- MHP allows to reduce salt and sugar added for food preservation.

Electric Field AC treatment (20kHz,<1kV/cm)

High viscosity Liquid (Miso paste)

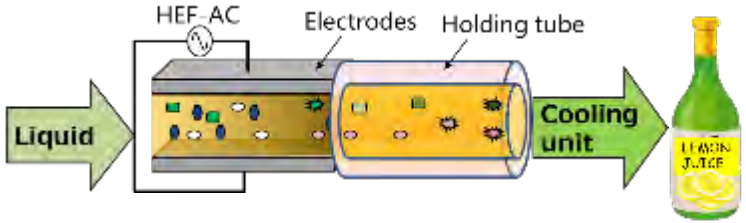


・Kills *Bacillus* spores to 1/500.

Reaches to 95℃ in 4s

High Electric Field AC treatment (20kHz, >1kV/cm)

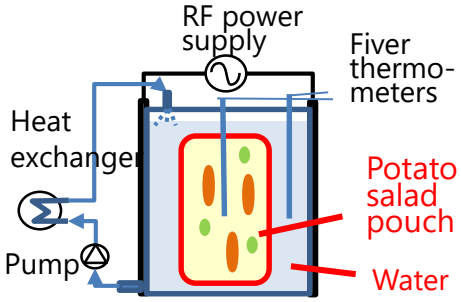
Low viscosity Liquid (fruit juice)



・Reduce discolor by 80%, cocked odor by 75%, Vitamin C lost by 90%.

Radio-Frequency Heating of food pouches in water (27MHz, <100V/cm)

Cooked food pouches



・Kill *E.coli* to $1/10^6$ and cucumber is still crunchy.

Seafood Pouches

・Shorten heating time to 1/3.
・ Back born of the fish is softened.

Smart Processing - Medium High Hydrostatic Pressure Technology-

NARO

NARO MHHP

Medium HHP at medium high *T*

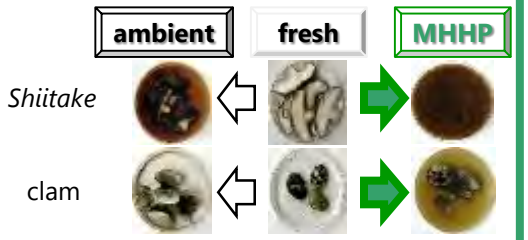
100 MPa
60 – 80 °C

Fruit Compotes
quasi-fresh flavor and texture out of harvest seasons

Fresh flavor and texture can be maximized by efficient liquid impregnation (vacuum and MHHP treatments) and sufficient pasteurization at medium high temperature, realizing long refrigeration.

High quality compotes of fruits with short harvest seasons (1 – 2 months) can be distributed year-round.

Broth
thorough enzymatic digestion



MHHP enhances enzymatic digestion, probably due to an accelerated impregnation of enzyme solution into the tissue.

Hygiene guaranteed under MHHP.

HHP

HHP at low *T*

600 MPa
5 - 10 °C

Juice
fresh flavor and taste

HHP-processed juices in USA (Starbucks)

Refrigeration storage for 1 – 2 months, owing to cold pasteurization, which retains fresh color (esp., green), flavor, and nutrients

World-wide growing market except Japan (due to Food Sanitation Law)

Meat Products
no preservatives

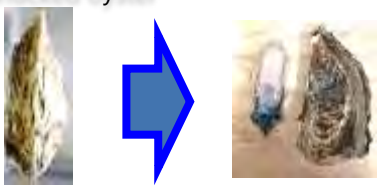
First HHP-processed meat products

Suppressing growth of lactic acid bacteria while minimizing a risk of pathogen contamination. No preservatives will be required for long refrigeration storage.

For microbial control of quality and/or hygiene

Shucking
toward automatization

HHP-shucked oyster

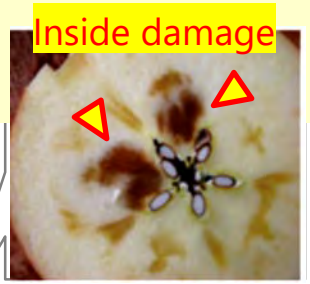


HHP shucking solves a labor shortage, due to the high throughput processing. Low risk of shell piece contamination benefits oyster processors.

Additional measures required for norovirus contamination

– Non-destructive quality testing of agro-products -

- The novel system for non-destructive quality testing of agro-products by NIRS.
- The system enables expecting one-month-later quality (accuracy>90%) and ripeness of fresh fruit.
- The system helps to decide appropriate time to eat.



Farms

Apples

Peaches

Packaging house

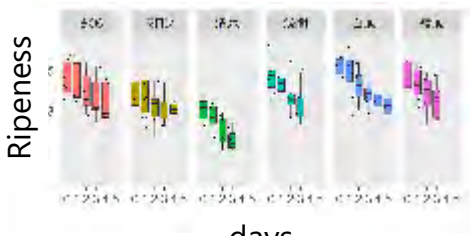
Inside damage prediction

- Very likely → Processing
- Unlikely

Ripeness prediction

- Full ripe
- Immature → Storage

Fresh fruit market



Thank you very much for your attention