

# Radiation Processing in Agriculture: Mutation Breeding, Food Irradiation, and Phytosanitary Irradiation

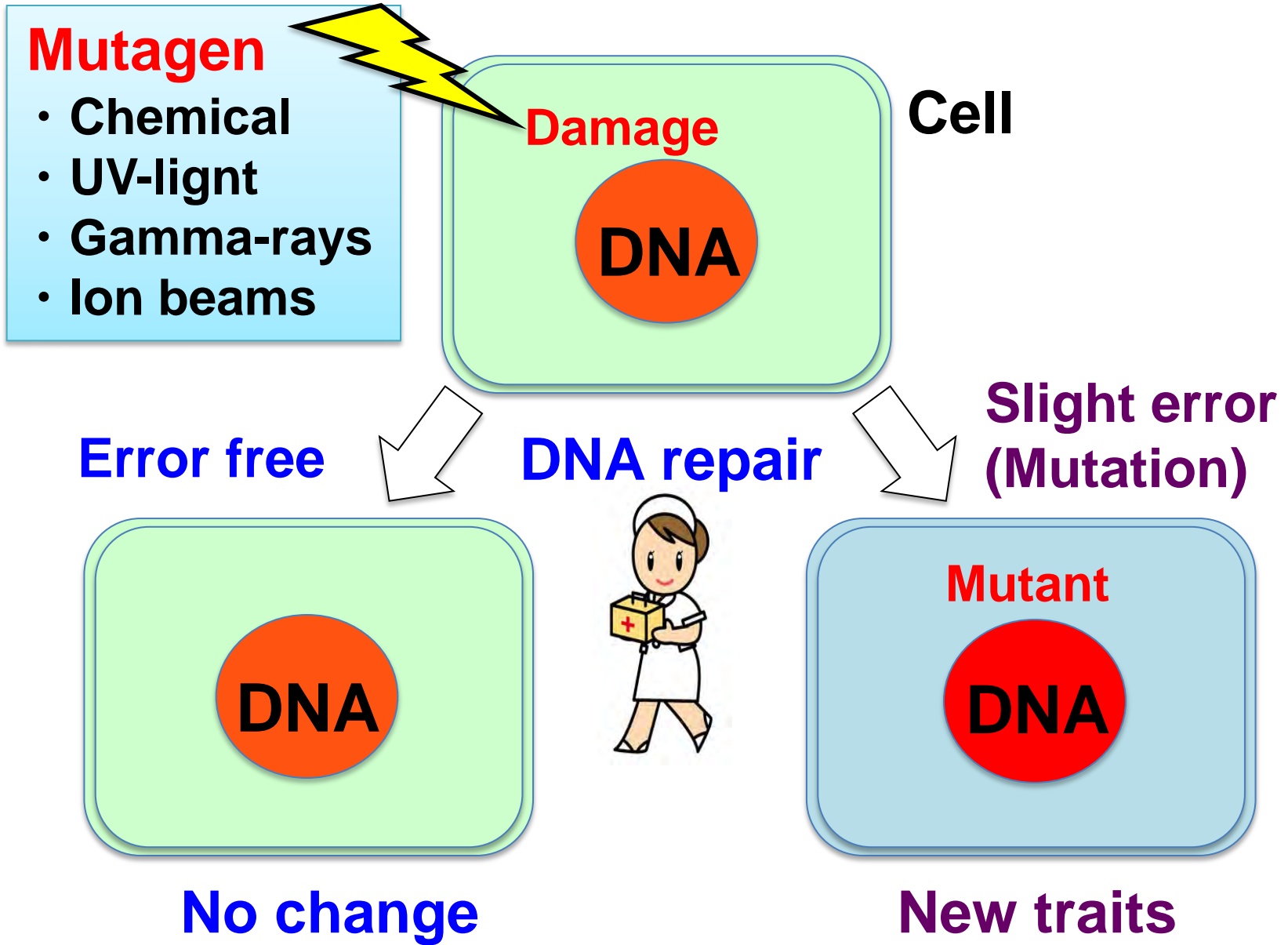
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# Mutation Breeding



# Discovery of Artificial Mutation Induction

1928



Total number of head progenies examined

**Mutation differs among tillers**

X-ray treated:

Higher voltage

Heavy dose ..... 210                      6

Light dose ..... 259                      1

Lower voltage:

Heavy dose ..... 4

Light dose ..... 2

Total X-rayed ..... 1,243                      14

**Mutation rate increased**

Radium treated:

Total for all doses ..... 1,039                      3

Untreated ..... 1,341                      0

**Dr. Lewis J. Stadler**

# Mutant Variety Database

IAEA NUCLEUS MVD



Home Search Variety Registration Joint FAO/IAEA Division

3,283 mutant varieties have been registered !!



Joint FAO/IAEA Programme  
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Division  
of Nuclear Techniques in  
Agriculture

Plant Breeding and  
Genetics Subprogramme

## Welcome to the Joint FAO/IAEA



## Background

The application of mutation techniques has generated a genetics and advanced genomics studies. The widespread generated thousands of novel crop varieties in hundreds

The FAO/IAEA Mutant Variety Database or MVD collects Data on the mutagen and dose used, the characters imp the database is to demonstrate the significance of mutati a platform for breeders to showcase their varieties to a g studies.

Pages: 33 | Records: 3,283  
 First Prev Next Last Page 33 Page Size 100

Variety Name	Latin Name	Common Name	Country	Registration
Zhangchun 10	Triticum aestivum L.	Wheat	China	1987
Zhangchun 12	Triticum aestivum L.	Wheat	China	1990
Zhangchun 13	Triticum aestivum L.	Wheat	China	1991
Zhangchun 14	Triticum aestivum L.	Wheat	China	1991
Zhangchun 17	Triticum aestivum L.	Wheat	China	1998
Zhangchun 18	Triticum aestivum L.	Wheat	China	1998
Zhangdou 1	Glycine max L.	Soybean	China	1980
Zhangnong 10	Setaria sp.	Millet	China	1966
Zhangnong 11	Setaria sp.	Millet	China	1966
Zhaoyang	Rosa sp.	Rose	China	1984
Zhe 101	Oryza sativa L.	Rice	China	2005
Zhe 852	Oryza sativa L.	Rice	China	1989
Zhefu 201	Oryza sativa L.	Rice	China	2005
Zhefu 218	Oryza sativa L.	Rice	China	1995
Zhefu 504	Oryza sativa L.	Rice	China	1999
Zhefu 7	Oryza sativa L.	Rice	China	1994
Zhefu 762	Oryza sativa L.	Rice	China	1993
Zhefu 802	Oryza sativa L.	Rice	China	1990
Zhefu 9	Oryza sativa L.	Rice	China	1990
Zhefu 910	Oryza sativa L.	Rice	China	2000
Zhefulangyou 12	Oryza sativa L.	Rice	China	2009
Zhejiang 28	Oryza sativa L.	Rice	China	2008
Zhejiang 41	Oryza sativa L.	Rice	China	2009
Zhemai 3	Triticum aestivum L.	Wheat	China	1983
Zhemai 4	Triticum aestivum L.	Wheat	China	1989
Zhemai 5	Triticum aestivum L.	Wheat	China	1991
Zhenfu 1	Oryza sativa L.	Rice	China	1971
Zhengguang 1	Oryza sativa L.	Rice	China	1978
Zhengliufu	Triticum aestivum L.	Wheat	China	1979
Zhengzhi 97C01	Sesamum indicum L.	Sesame	China	2002
Zhengzhi 98N09	Sesamum indicum L.	Sesame	China	2004
Zhengzhondajiangzhang	Rosa sp.	Rose	China	1986
Zhengzhouchunse	Rosa sp.	Rose	China	1989
Zhenjie	Rosa sp.	Rose	China	1986
Zhenuo #3	Oryza sativa L.	Rice	China	2003
Zhenuo 2	Oryza sativa L.	Rice	China	1993
Zhenuo 3	Oryza sativa L.	Rice	China	2003
ZHENUO 36	Oryza sativa L.	Rice	China	2003

### Most Recent Varieties

Variety Name	Latin Name
Binadhan-19	Oryza sativa L.
Binamasur-11	Lens culinaris Medik.
Binamoog-9	Vigna radiata (L.) Wil.
CBC5	Vigna unguiculata Walp.
DT2010	Glycine max L.



hide of as



# Energy Deposition: Gamma-ray vs Ion Beam

## Gamma-rays (electromagnetic wave)

$^{60}\text{Co}$  source



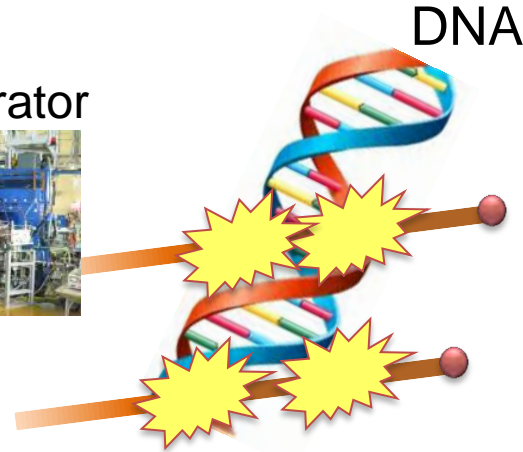
DNA

Produce ionization sparsely  
(Low-LET radiation)

LET:  $\sim 0.2$  keV/mm

## Ion Beams (energetic particles)

Accelerator



DNA

Produce dense ionization  
along the track of ion particles  
(High-LET radiation)

LET:  $1 \sim 2,000$  keV/mm

# Mutant Varieties Developed using TIARA



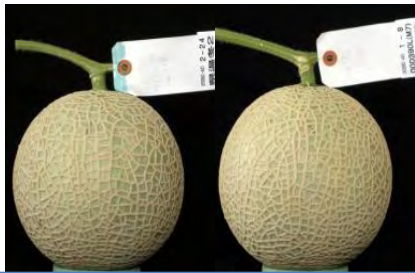
**Chrysanthemum**  
6 varieties 1998



**Carnation**  
8 varieties 2002~2014



**Chrysanthemum**  
8 varieties 2005~2017



**Melon (Low-temp. tolerant)** 2011



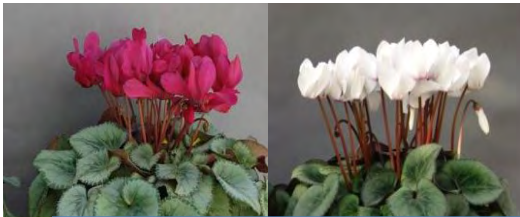
**Osteospermum**  
2 varieties 2007~



016



**Low-Cadmium rice** 2012



**Fragrant cyclamen**  
3 varieties 2012~2015



**Creeping fig (NOx absorption)** 2007



**Victory bouquet**  
GP of Figure Skating Final 2017

# Food Irradiation

Non-heating, non-chemical processing

## *Why Irradiate Food?*

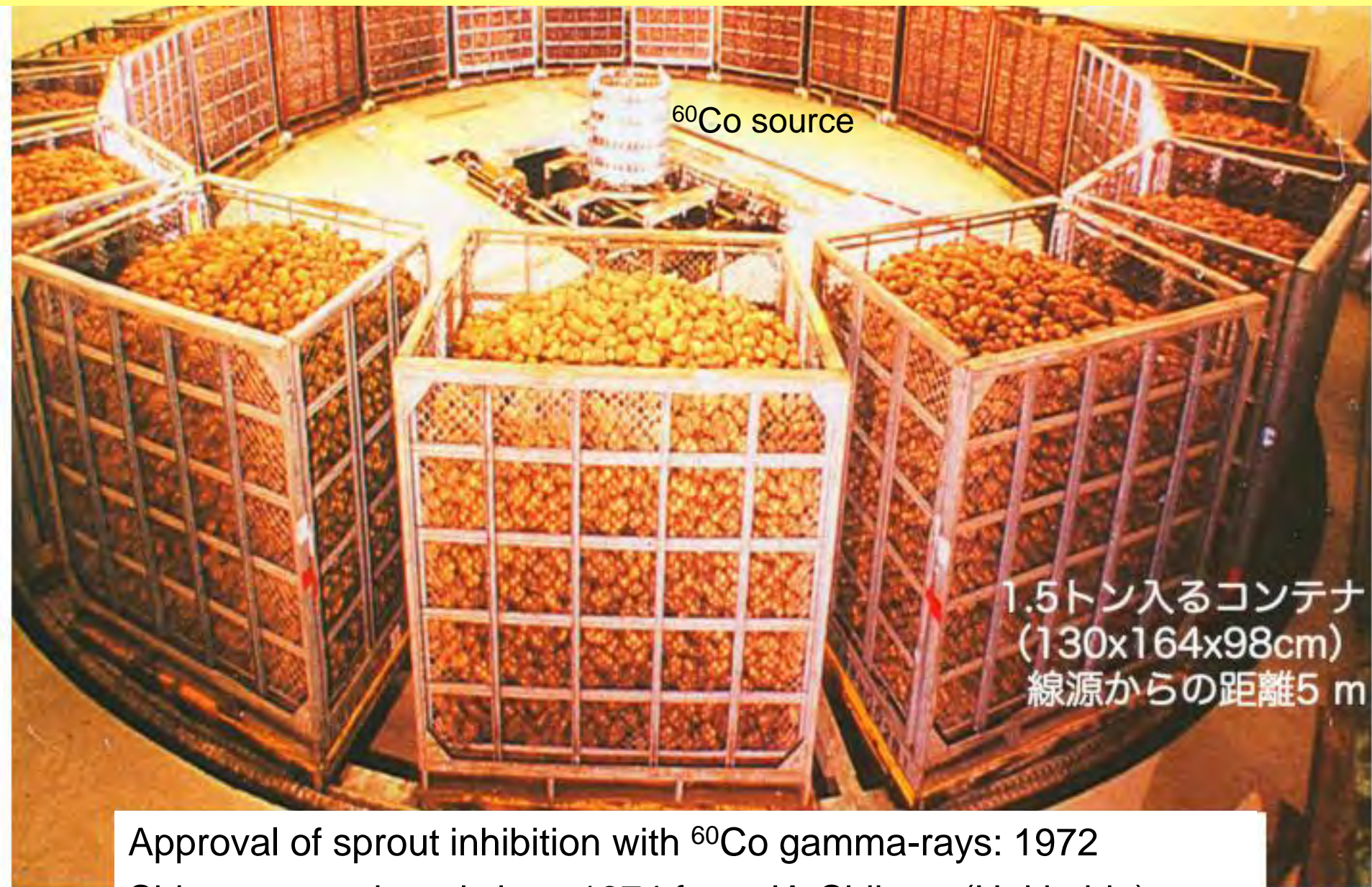
- Delay of Sprouting/Rooting
- Control of Insects
- Prevention of Foodborne Illness
- Sterilization

## *How Is Food Irradiated?*

- Gamma rays from  $^{60}\text{Co}$  or  $^{137}\text{Cs}$
- Electron beam (accelerated electrons)
- X-rays (Bremsstrahlung)



# Stable supply of potatoes in off season



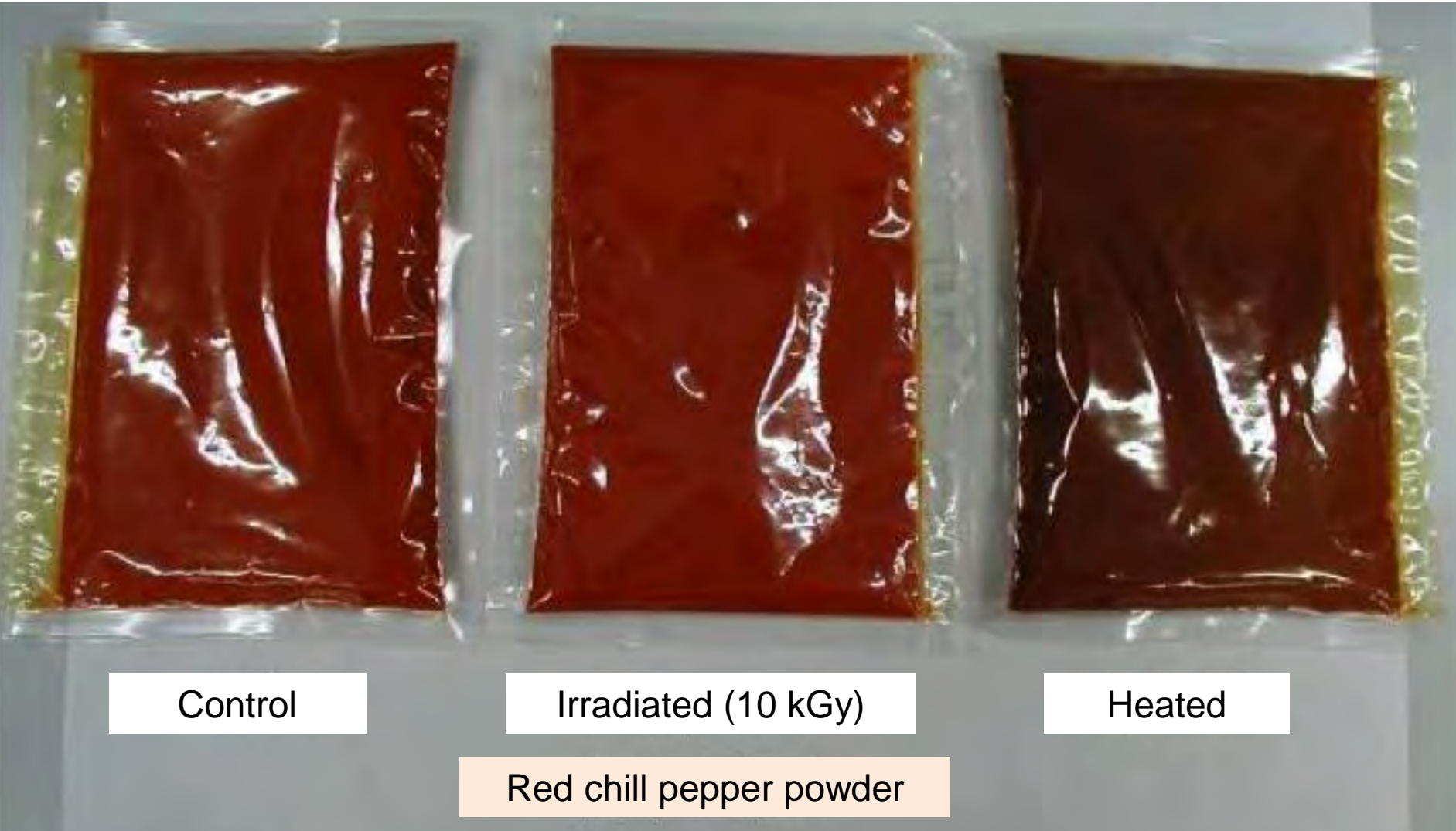
$^{60}\text{Co}$  source

1.5トン入るコンテナ  
(130x164x98cm)  
線源からの距離5 m

Approval of sprout inhibition with  $^{60}\text{Co}$  gamma-rays: 1972  
Shipment continued since 1974 from JA-Shihoro (Hokkaido)



# Difference of colors between irradiated red pepper powder and those sterilized by heat



Microbial control of food ingredients, spices, herbs and dehydrated vegetables

# Reduction of post-harvest losses



Irradiated (2.8 kGy)

Control

Strawberries wrapped by cellophane were irradiated by gamma ray from Co-60 and had been kept at 4 deg-C for 5 days, then at room temperature for 2 days.

高崎女子高校スーパーサイエンスハイスクール  
2006年研究課題「放射線の殺菌作用」より

# Irradiated ground beef burgers (frozen)



Eliminate organisms that cause foodborne illness, such as Salmonella and *E. coli*



# China – Spicy pickled chicken feet / wings

## 中国の味付き鶏脚/手羽先

Courtesy of Mr. Henon

- **Popular snack found in convenience stores across China.**  
中国全土のコンビニで見かけるポピュラーなスナック
- **Irradiation allows minimum boiling for better texture**  
照射することで茹で時間を最小限にでき、テクスチャー良好
- **Shelf-life at room temperature > 6 months**  
室温での日持ち6ヶ月以上
- **> 350,000 tons irradiated in 2017**  
2017年の処理量は35万トン以上
- **Two major manufacturers have own irradiator**  
2つの主要生産施設は自社で照射設備を保有



irradiated



# Country irradiating food the most

Courtesy of Mr. Henon

最も食品照射の処理量が多い国、中国

## China

- > 1 million tons of food irradiated yearly\*
- In ~100 irradiation facilities, increasingly by accelerated electrons

- ・ 全照射処理量の70%が食品
- ・ 年間100万トンを超える食品を照射
- ・ 約100の照射施設で処理、電子線処理が増加中





# Phytosanitary irradiation 植物検疫のための照射

Courtesy of Mr. Henon

- **Damage caused by invasive insects: 70 billion USD per year**

侵入害虫による被害：年間700億米ドルと推定

- **International trade, tourism + Global warming = spread of insect invaders**

国際貿易、観光旅行＋地球温暖化＝侵入害虫の拡散

- **Irradiation now recognized as an effective phytosanitary treatment by the International Commission on Plant Protection (IPPC)**

現在、照射処理は効果的な植物検疫処理として国際植物防疫条約（IPPC）で認められている

**International standards: ISPM 18 and ISPM 28**

国際基準：

（照射の一般指針）植物検疫措置としての放射線照射のための指針（ISPM No.18）  
（具体的な処理基準）規制有害動植物のための植物検疫処理（ISPM #28）





# Phytosanitary treatment:

Irradiation as a quarantine measure decreases the need for other pest-control practices that may harm the fruit

There are currently 24 fresh fruit and vegetables with FSANZ approval for irradiation.



[www.mpi.govt.nz](http://www.mpi.govt.nz) • 12

Blueberries and Raspberries should be approved later this year

# Export of irradiated produce from Australia

## オーストラリアからの照射農産物の輸出

Product	2017-18 (estimate Feb 2018)		2016-17
	Exported to	Tons	Tons
Table Grapes	Viet Nam	1 780	1109
Mangoes	New Zealand	1 290	982
Cherries	Viet Nam	370	0
Tomatoes	New Zealand	220	134
Lychees	New Zealand	200	72
Mangoes	USA	100	141
Papaya	New Zealand	22	0
Mangoes	Malaysia	14	0
Lychees	USA	12	6
Capsicums	New Zealand	9	0
Mandarins	Viet Nam	6	161
Strawberries	Indonesia	2	0
Blueberries	Indonesia	1	0
<b>TOTAL</b>		<b>4 027</b>	<b>2 723</b>



**+50%**

# Summary

- The ionizing radiation has been utilized as a tool of cultivar improvement, sprouting/rooting inhibition.
- Most irradiated products are spices, herbs and dehydrated vegetables.
- Also successful in niche applications such as frozen legs and pickled chicken snack.
- Use of irradiation as a quarantine treatment shows rapid rise in recent years.