

## **Research Achievements and Strategies for Production of Rice with High Quality in Japan**

**Tokio Imbe**

Rice Breeding Research Team

**National Institute of Crop Science(NICS)**

National Agriculture and Food  
Research Organization (NARO)



### **Rice Production in Japan (2002)**

- Total Land Area            37,780,000 ha
- Cultivated Area            4,762,000 ha
- Paddy field                2,607,000 ha
- Rice cultivated Area    1,683,000 ha (64.6%)  
    ( Upland rice field:        5,560ha)
- Average Yields (brown rice base)  
    Paddy rice:                5.27t/ha  
    Upland rice:                2.25t/ha

## Problems in the Rice Production

- Overproduction  
[ Decline in per capita consumption,  
=59.7kg (2003) Peak=118kg (1964)]
- Decreasing or aging of rice farmers
- High cost of production
- Less diversity



**Table 1. Leading rice varieties in Japan (2004)**

Variety	Area (1000ha)	(%)	Year of Release	Cross Combination
1 Koshihikari	557.8	37.7	1956	Norin 22 / Norin 1
2 Hitomebore	154.5	10.5	1991	Koshihikari / Hatsuboshi
3 Hinohikari	148.3	10.0	1989	Koganebare / Koshihikari
4 Akitakomachi	130.4	8.8	1984	Koshihikari / Ouu 292
(Total of top 4 varieties)		<b>67.0</b>		
5 Kinuhikari	51.2	3.5	1988	Shu2800 / Hokuriku 100 // Hokuriku 96
(Total of top 5 varieties)		<b>70.5</b>		
6 Kirara 397	48.8	3.3	1988	Shimahikari / Kitaake
7 Haenuki	43.9	3.0	1991	Shounai 29 / Akitakomachi
8 Hoshinoyume	38.7	2.6	1996	Akitakomachi / Douhoku 48 // Kirara 397
9 Tsugaru Roman	24.0	1.6	1995	Fukei 141 / Akitakomachi
10 Nanatsuboshi	17.1	1.2	2001	Hitomebore / Kukei90204A // Akiho
(Total of top 10 varieties)		<b>82.2</b>		

<b>Table 2. Leading Rice Varieties (1970)</b>					
	Vriety	Area (1000ha)	(%)	Year of Release	Cross combination
1	Nipponbare	210.1	8.3	1963	Yamabico/Sachikaze
2	Honenwase	165.5	6.5	1955	Norin 22/Norin 1
3	Koshihikari	150.1	5.9	1956	Norin 22/Norin 1
4	Reimei	136.4	5.4	1966	Co60 mutant of Fujiminori
5	Sasanishiki	127.8	5.1	1963	Ouu 224/Sasashigure
	(Total % of top 5 varieties)		<b>31.2</b>		
6	Fujiminori	113.6	4.5	1960	Norin 17/Fujisaka 5
7	Reiho	91.8	3.6	1969	Hoyoku/Ayanishiki
8	Kimmaze	55.7	2.2	1948	Ryosaku/Aichi Nakate Asahi
9	Nakate-Shinsenbor	53.1	2.1	1950	Norin 22/Hayabusa Megurosakaemochi/
10	Shiokari	45.5	1.8	1963	Kyouwa//Kyouwa
	(Total % of top 10 varieties)		<b>45.4</b>		
	(Total of 70 varieties :		<b>80.0</b>	)	

<b>Changes in blast resistance in Tohoku varieties (Higashi 1996)</b>				
Year	Variety	Area (1000ha)	Resistance to leaf blast	Resistance to panicle b.
1975	Toyonishiki	149	3	3
	Sasanishiki	117	6	7
	Kiyonishiki	106	4	5
	Reimei	65	3	3
	Sasaminori	30	3	4
	Fujiminori	26	3	3
	<b>Weighted mean</b>			<b>3.9</b>
1995	Hitomebore	117	6	5
	Akitakomachi	102	5	6
	Sasanishiki	74	6	7
	Mutsuhomare	47	4	4
	Koshihikari	37	7	7
	Haenuki	31	5	5
	<b>Weighted mean</b>			<b>5.5</b>

**Diseases: blast, sheath blight, strip virus,  
bacterial leaf blight, bacterial grain rot...**



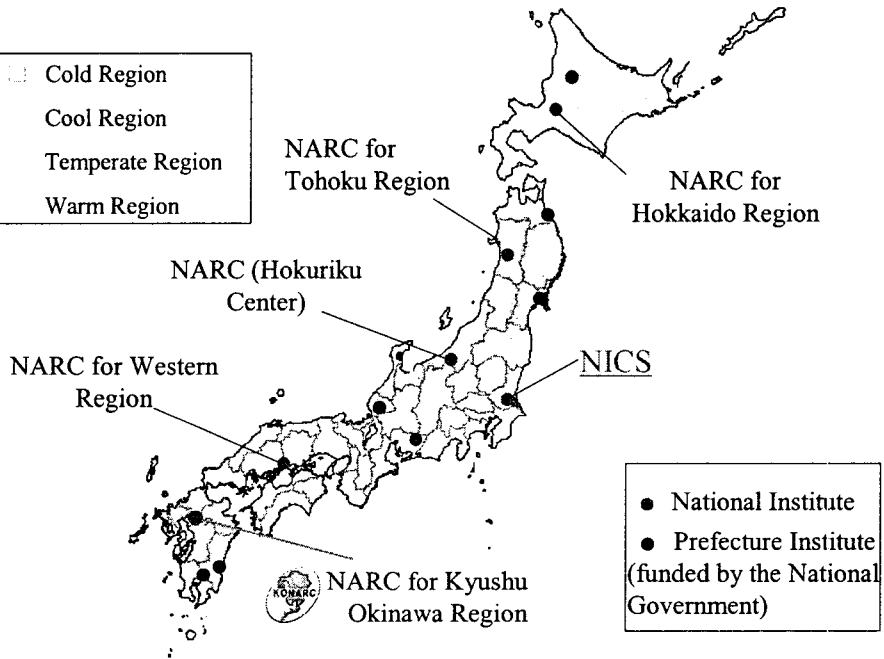
**Insects: BPH, GLH,  
stem borer, leaf folder,  
rice-bugs...**

**Abiotic stress:  
cold damage , high temperature ...**

## **Strategies of the Rice Breeding**

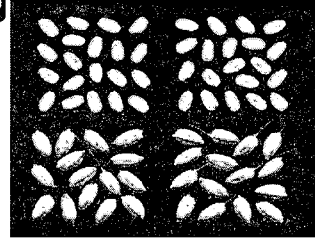
- To utilize the paddy field more efficiently:
  - ☆ Late planting or seeding for double cropping with wheat
  - ☆ Rice for WCS
- To expand rice demand:
  - ☆ New traits; Low amylose, low glutenin, hypoallergenic, colored grain, giant embryo
- For reduction of labor and production cost:
  - ☆ Direct seeding, multiple resistance to pests and diseases

- Cold Region
- Cool Region
- Temperate Region
- Warm Region



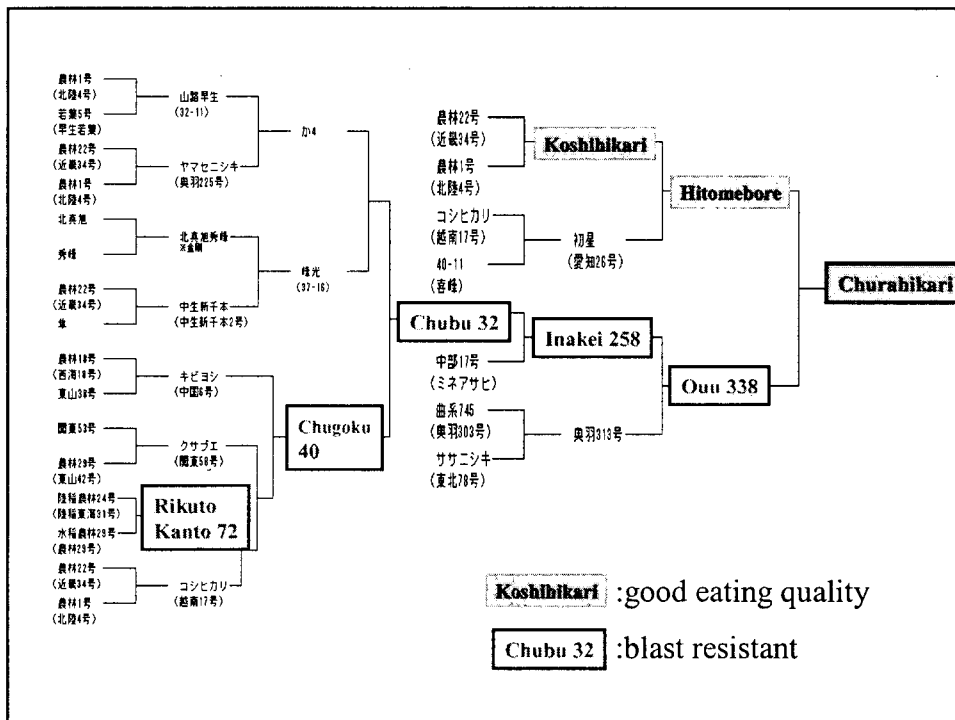
## Combining Palatability and Disease Resistance

“Churahikari”, a new rice variety with  
excellent palatability and high blast

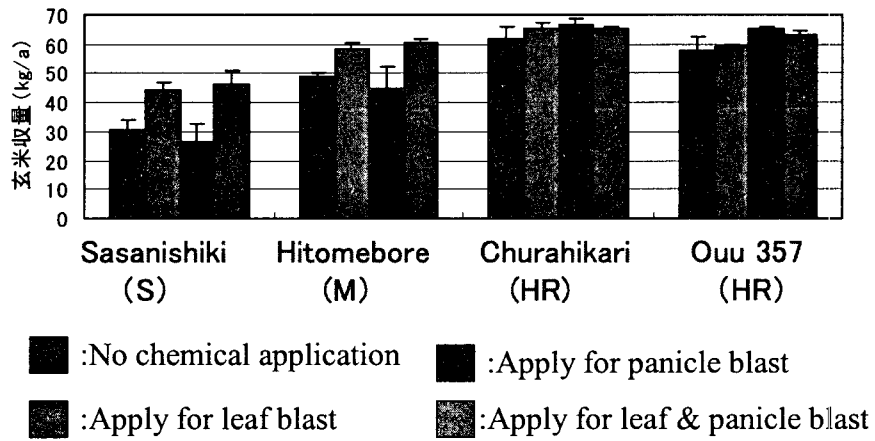


Churahikari  
(resistant)

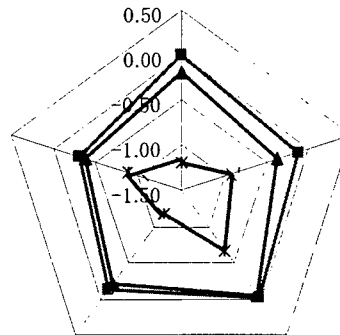
Sasanishiki  
(susceptible)



## Blast-resistant “Churahikari” does not need chemical control of blast disease



## “Satojiman”, a new rice variety with excellent palatability and stripe-virus resistance



- Satojiman
- ▲— Koshihikari
- ⊕— Asanohikari



**Palatability Test: Sensory  
and Physicochemical Test**



# Palatability Test of Rice Grains

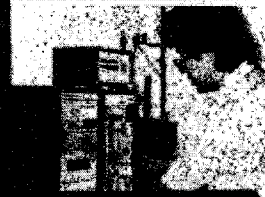
## Sensory Test

1. Fundamental Test
2. Multi-sided Test  
(taste, appearance, etc)
3. Labor, Time consuming
4. Difference of Preference

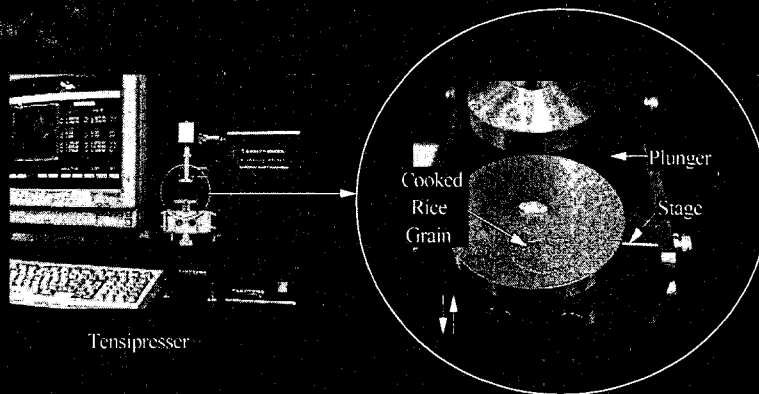


## Physicochemical Test

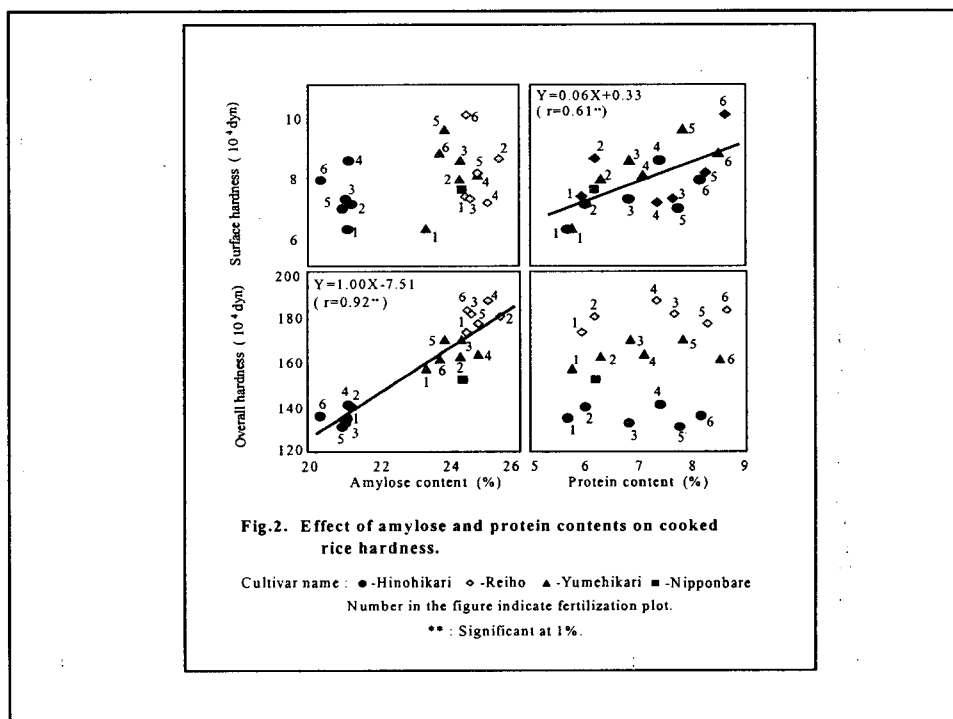
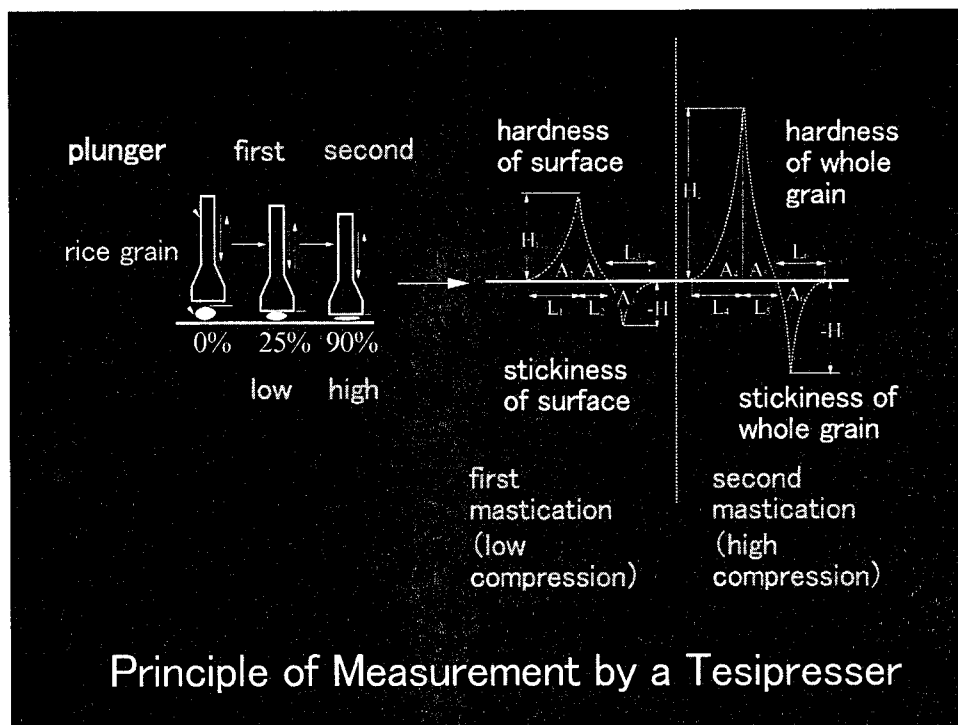
1. Indirect Estimation
2. Single-Purpose Test
3. Labor, Time-Saving
4. No Effect of Preference
5. Universal Test



## Physical analysis of eating quality

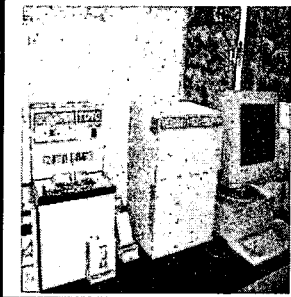


Texture measurement of single rice grain  
by a Tensipresser



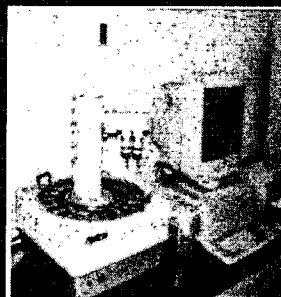
# Novel Palatability Sensing Systems

Appearance



Midometer

Taste



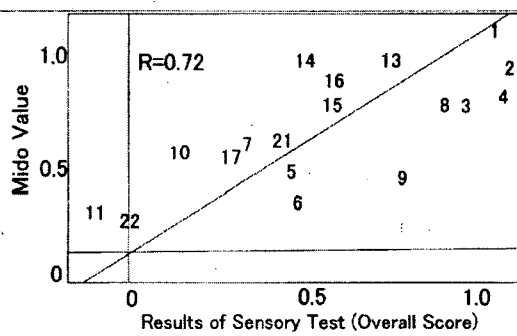
Taste Sensor

Aroma



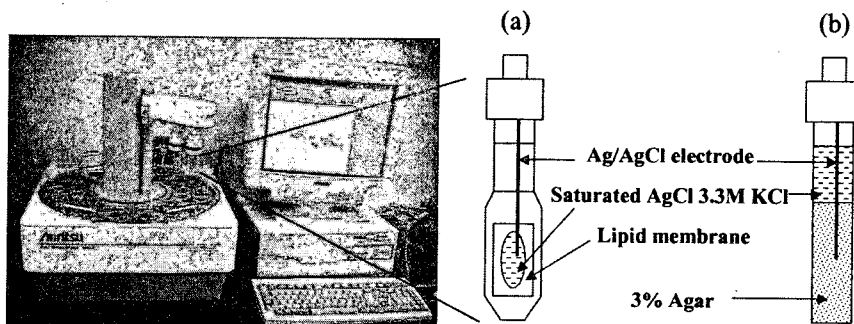
Electronic Nose

Relationship between Palatability and Mido value



1:Koshihikari, 2:UoKoshi, 3:Hitomebore, 4:Hino hikari, 5:Hatsuboshi, 6:Sasanishiki, 7:Chiyonishiki, 8:Hoshinoyume, 9:Kirara-397, 10:Mutsuhomare, 11:Asanohikari, 13:Hatsushimo, 14:Naka-shin, 15:Akebono, 16:Asahi, 17:Toyonishiki, 21:Kinuhikari, 22:Nipponbare

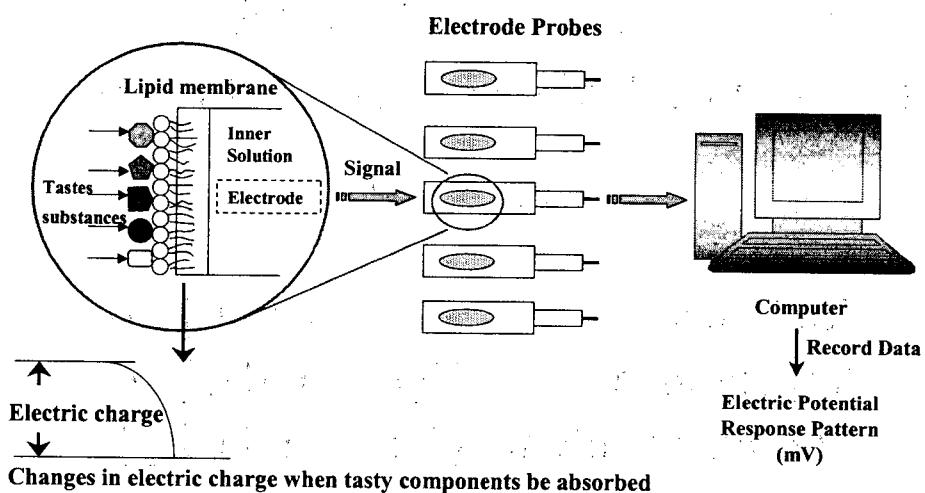
## Taste Sensing System, SA402 Anritsu



(a) Lipid membrane electrode

(b) Reference electrode

## Principle Responses of the Taste Sensing System

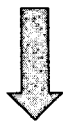


## Genetic Analysis of Palatability

Fukui Station

**Koshihikari × Akihikari**  
excellent(2)      Acceptable(5)

Doubled haploid lines = DHLs 146 lines



Palatability Test

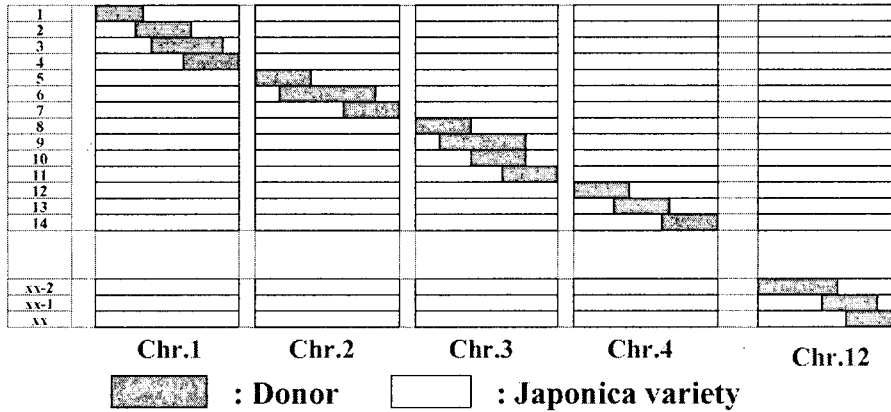
Stickiness : Chr. 2 and Chr.6

Appearance : Chr. 2 and Chr.6

Amylose content : Chr. 2 and Chr.6

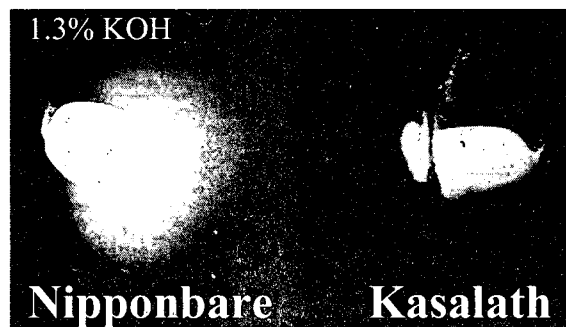
## Chromosomal Segment Substitution Lines (CSSL) for QTL analysis of wild relatives and indica varieties

CSSL No.



**Analysis of complicated traits, such as  
yield, eating quality, etc.**

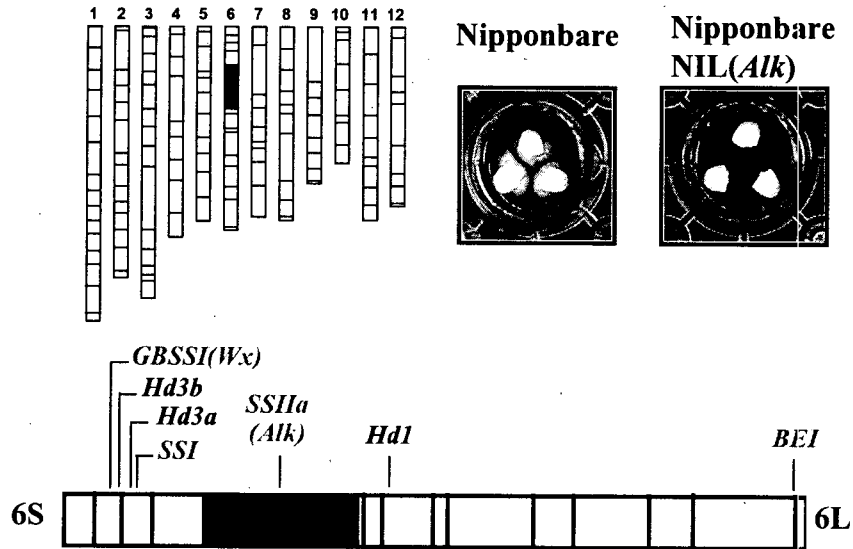
## Influence of the gene for alkali disintegration (*alk*) to palatability



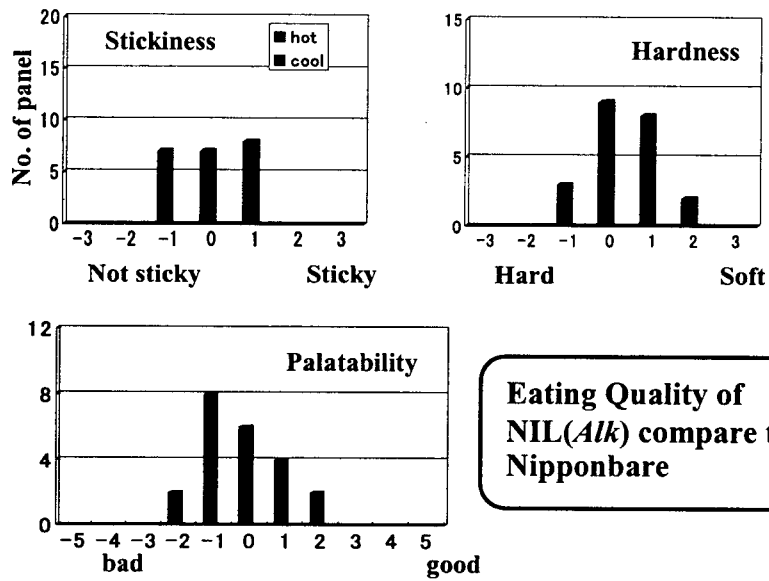
Alkali disintegration (*alk*)

Umemoto *et al.* 2002 Theor. Appl. Genet.

## Selection of Near Isogenic Line (*Alk*)

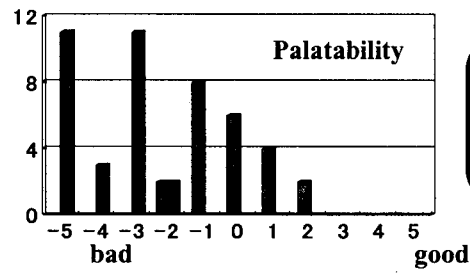
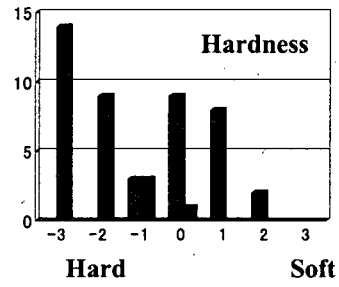
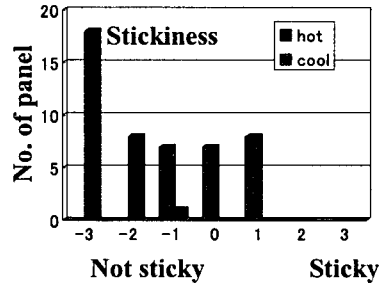


## Eating quality and Alkali disintegration



Eating Quality of  
NIL(*Alk*) compare to  
Nipponbare

## Eating quality and Alkali disintegration



**Eating Quality of  
NIL(*Alk*) compare to  
Nipponbare**



## Characteristics related to palatability

Physical characteristics

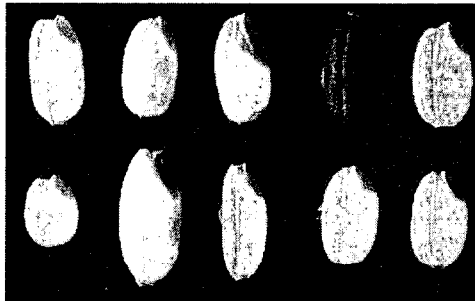
Amylose content

Amylopectin ?

Protein content

Protein ingredient (PBI, PBII)

## **New-trait, multi purpose use of rice**

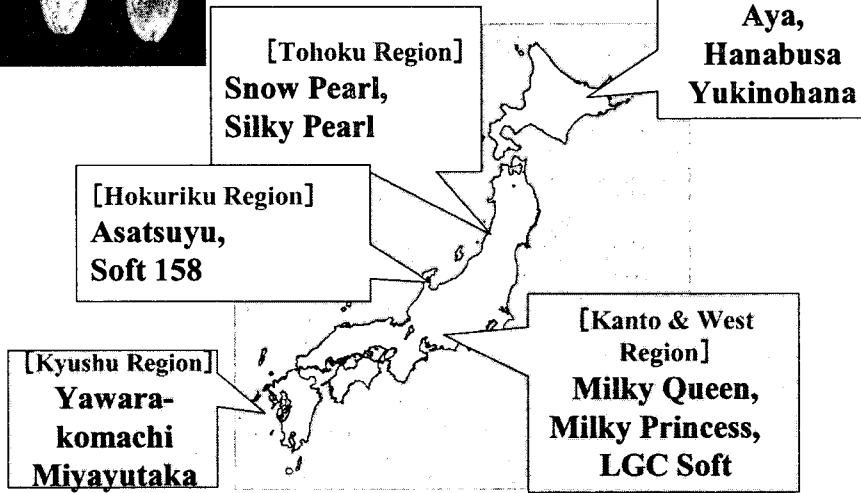


## Low amylose varieties

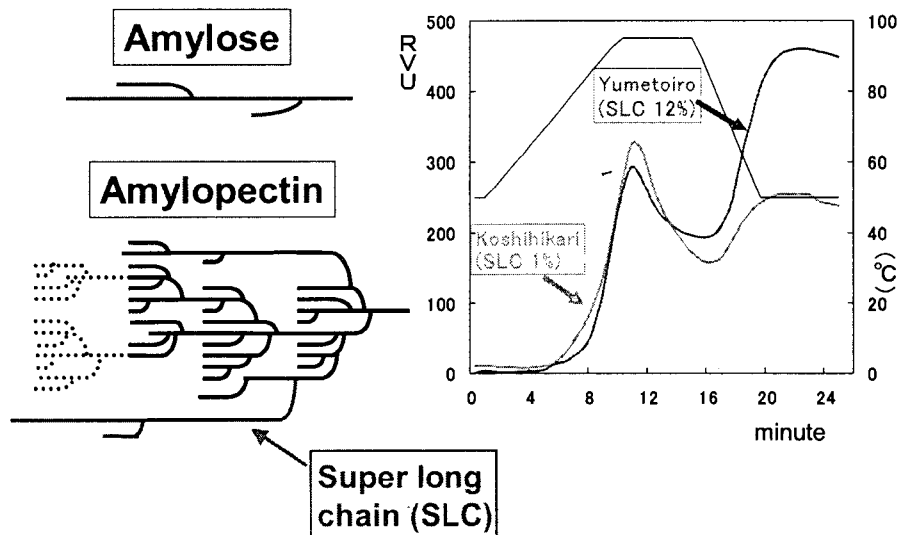


Normal variety : 17 ~ 23%

Low amylose : 9 ~ 12%

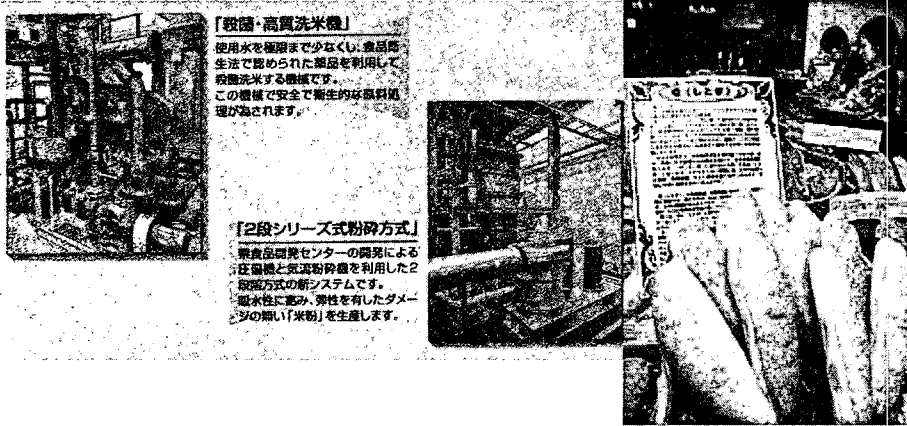


## Super long chain of amylopectin



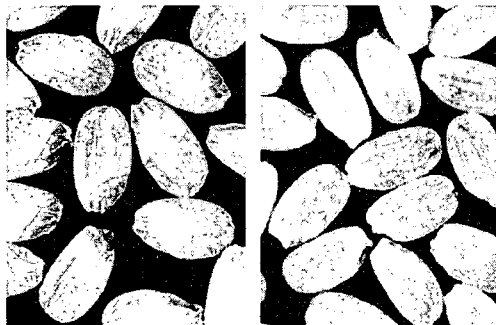
# Bread which is made of rice

● Fine grinding technology of rice powder



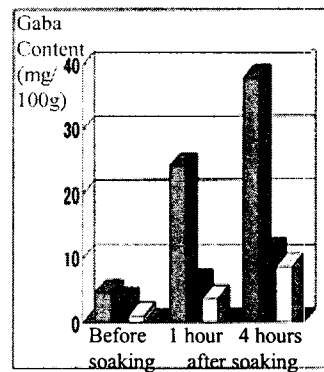
【森田元研究調査官作成】

## Giant Embryo Variety “Haiminori”



Haiminori

Koshihikari



Accumulation of  $\gamma$ -amino butyric acid (Gaba)

Note) Red:Haiminori, blue:Nipponbare white:Koshihikari

## Commodity of Pre-germinated Brown Rice

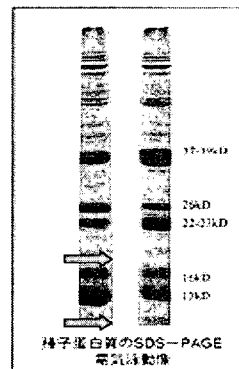


### Low glutelin rice varieties

- \* Unchanged total protein content
- \* Decrease rate of easy digestion.
- \* Increase rate of hard digestion.

λ Varieties;  
 LGC-1, Shun-you  
 +Good eating quality  
 adding low amylose trait  
 LGC-Soft

Reducing Low glutelin+ Lacking 26kDa globulin  
 → 50% decrease  
 LGC-Katsu, LGC-Jun



## Various color rice, Purple-Red-Yellow

λ Pericarp of brown rice contains coloring matter.

Purple-black rice: Anthocyan

Red rice: Tannin

λ Rich vitamin, iron and other minerals.

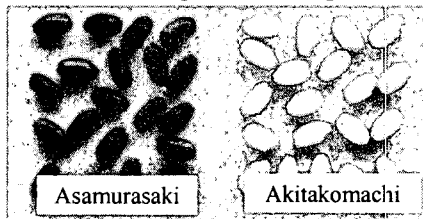
λ It is expected as diet food.

[Varieties]

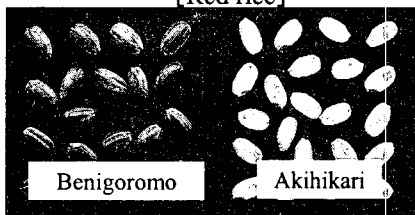
P-B rice: Asamurasaki, etc.

Red rice: Beniroman, Benigoromo

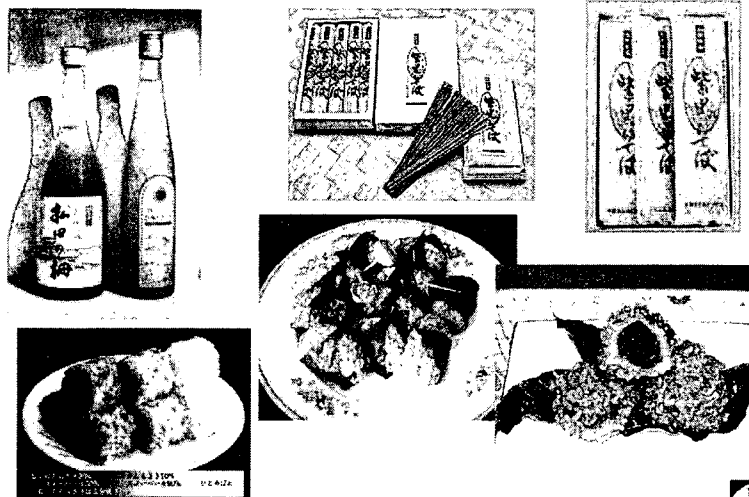
[Purple-black rice]



[Red rice]



## Commodities using purple rice





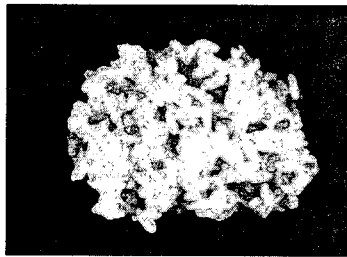
## Red Rice Cultivar for Kyushu

“Benizomemochi”

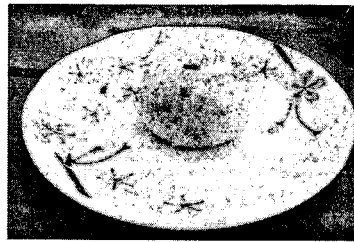
(Glutinous)



Benizomemochi    Tukushi-Akamochi

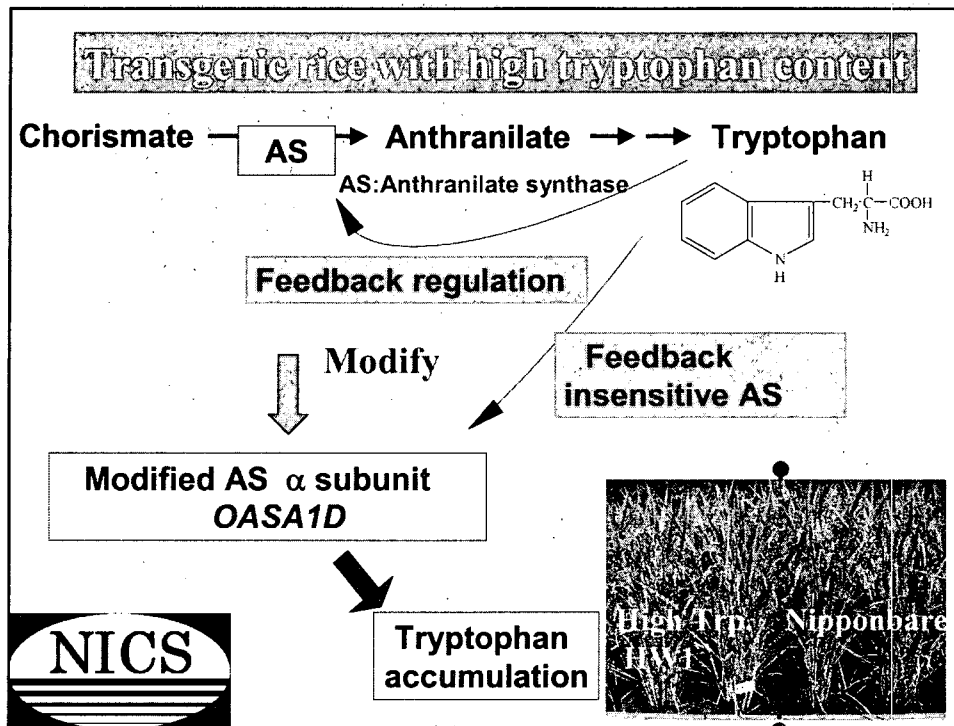


Steamed Rice

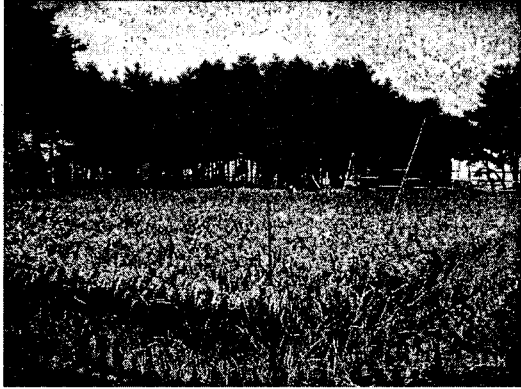


Japanese Traditional Rice Cake Made from Benizomemochi

**Genetic Engineering**



**\*High tryptophan rice in field**



**\*Transgenic rice for pollinosis, diabetes etc. are being developed at the National Institute of Agrobiological Science (NIAS).**

# Genomic Breeding

