

Characteristics and Improvement of Jeju Native Pig

2022. 10.26

Subtropical Livestock Research Institute,
National Institute of Animal Science, RDA

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Production of high meat pigs preferred by consumers and producers based on indigenous pigs species

1. Introduction of Subtropical Livestock Research Institute
2. Breeding history of Korea native black pigs
3. Development of new varieties 'Nanchukmacdon' and 'Wooriheukdon'
4. How is 'Wooriheukdon' and 'Nanchukmacdon' made?
5. Development of new varieties incorporating core technologies
6. The excellence of "Nanchukmacdon "
7. Consumer preference evaluation result
8. Current level of 'Nanchukmacdon'

History of Subtropical Livestock Research Institute, NLRI

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1956. 09.

Establishment of Jeju support for The Central Livestock Technology Institute

1962. 3.

Changed order to Jeju Test Center of RDA

2004. 01.

Renamed as Subtropical Agricultural Research Institute

1994. 12.

Changed to Jeju Agricultural Experiment Station of RDA

2008. 10.

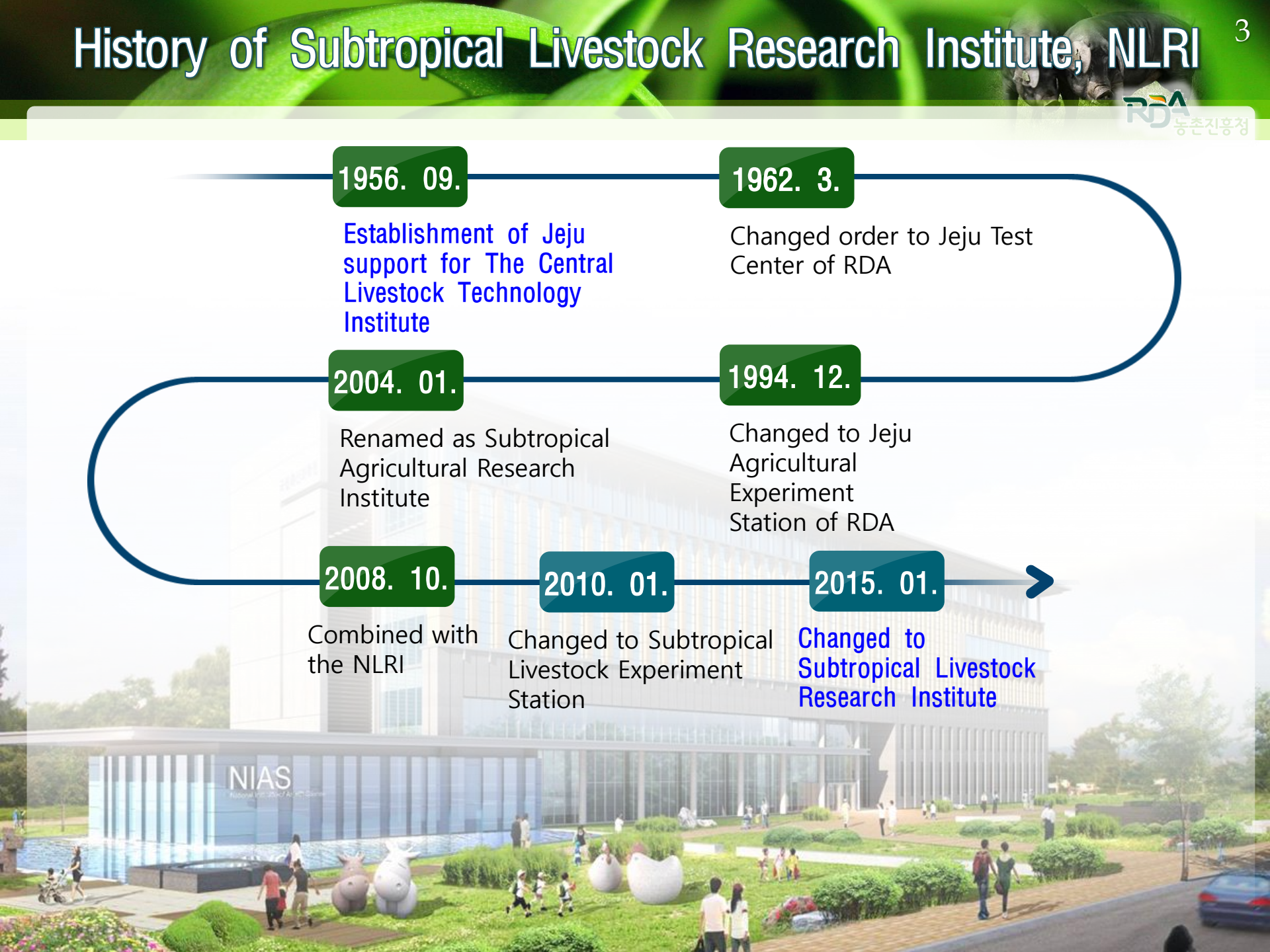
Combined with the NLRI

2010. 01.

Changed to Subtropical Livestock Experiment Station

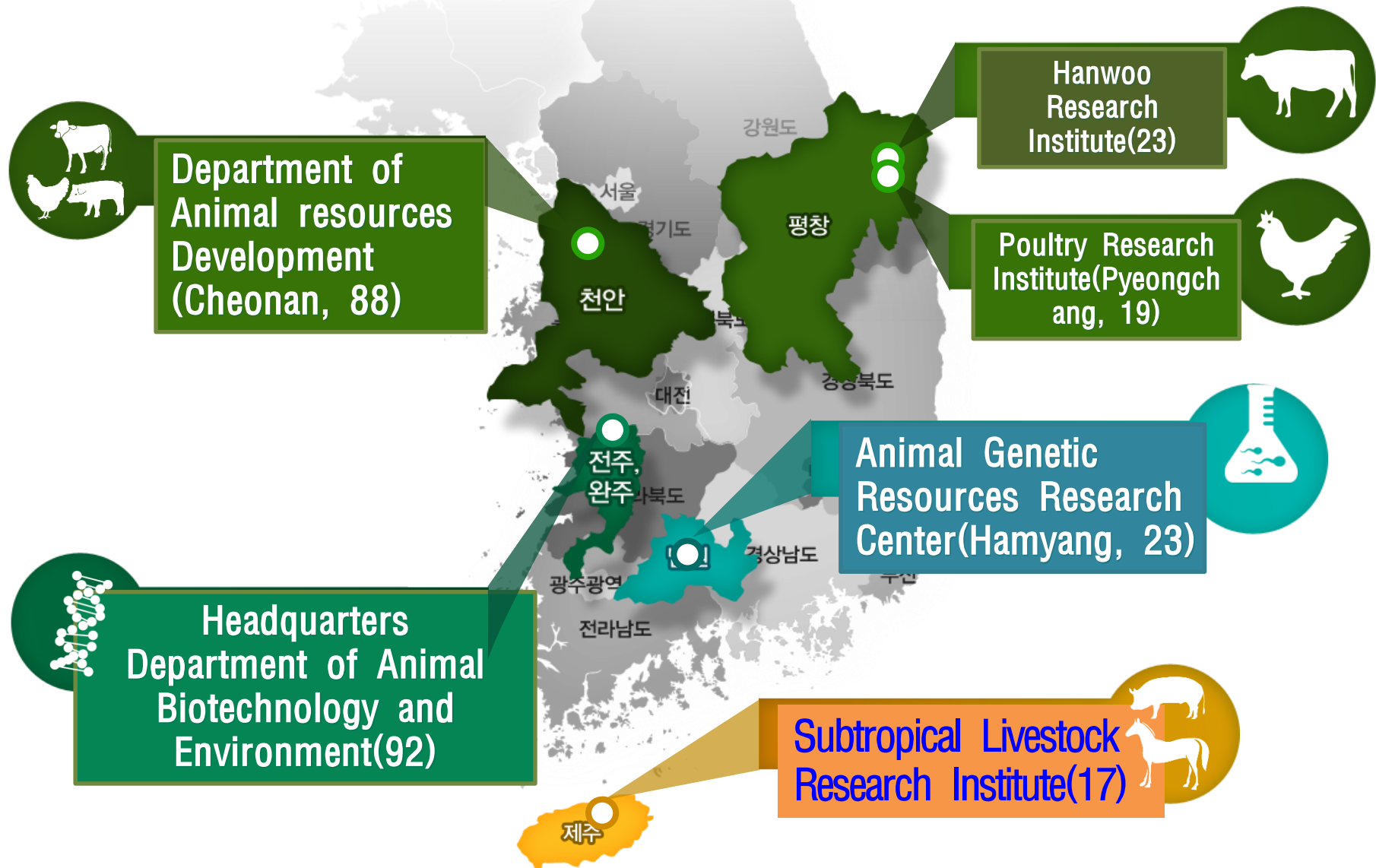
2015. 01.

Changed to Subtropical Livestock Research Institute



Location and Employee of National Institute of Animal Science(322)

RDA
농촌진흥청



Mission of the Subtropical(Nanji) Livestock Research Institute

(Livestock Breeding Laboratory, Livestock Production System Laboratory)

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Developing, Breeding, Use and Specification of Conventional Livestock(Black cattle, Native black pig)



Development of Horse Improvement, Preservation and Management Technology.



Study on Diagnosis and Prevention and Treatment of Disease in Livestock



Development of technology for fostering and using new varieties of subtropical forage crops





Cultivating a riding horse breed suitable for the Korean body type

❖ improvement target

- Height: 145~150cm, body type is a rectangle with a height of 1:1
- Hair color: black, black and white
- A horse with a gentle character and good endurance

The most important economic trait of a riding horse is good character.

- Establishment of character evaluation standards for domestic raised horses and investigation of related characteristics
 - Visual evaluation, touch evaluation, and auditory and tactile evaluation are conducted to evaluate the character of the riding horse.
 - Neurotransmitter and personality (anxiety, etc.) related personality score and gene comparison.



< breeding horse >



< 2nd generation >



<Beach Horse Riding>

Proliferation of Jeju Black Cattle and Establishment of Industrialization Foundation

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Investigation of genetic characteristics of Jeju black cattle and development of industrialization technology

❖ Jeju black cattle genotype analysis

Jeju black cattle

Korean beef

Holstein · Engus



E^+/E^+



$E^+/e, e/e$



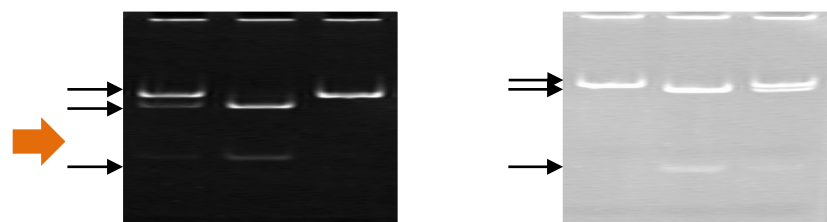
$E^D/-$



❖ Development of color identification technology for Jeju black cattle

E^D/E^+ E^D/E^D E^+/E^+

e/e E^+/e E^+/E^+

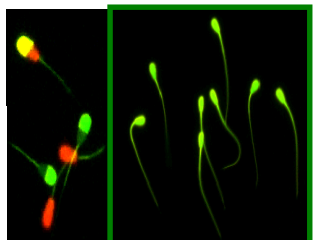


E^D : Dominant dark hair color gene
 E^+ : wild type hair color gene
 e : recessive red hair gene

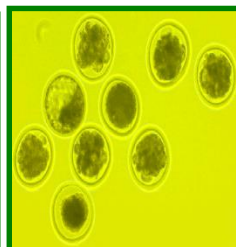
❖ Supply of Jeju Black Cattle Frozen Semen and Embryod to farms



< Bull(E^+/E^+) >



< sperm analysis >



<Embryo>

❖ Establishment of breeding foundation for Jeju black cattle farms



Breeding history of Korea native black pigs

- It is presumed that the breeding history of Jeju native black pigs began in the Goguryeo period when they were brought in from the mainland.
- Jeju Native Swine refers to pigs with black hair that have been adapted to the climate of Jeju for a long time.
- Although the body is small, the constitution is strong and disease-resistant, the number of pups produced is small, the growth rate is slow, but the meat quality is good.

<Jeju Black Pig>

- **Designated as Natural Monument No. 550 in 2015**
- The ears are small, not folded, but raised upwards, and about 260 are bred in Jeju Island.

Korea Native Pig



Jeju Native Pig



Development of new varieties 'Nanchukmacdon' and 'Wooriheukdon'

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Jeju Native Pig



Landrace



Duroc



Nanchukmacdon

Color: black
Weight: 200-220 kg (♀) 250-270 (♂)
Height: 70-75cm (♀) 85-90cm (♂)
Number of litters: 7-8

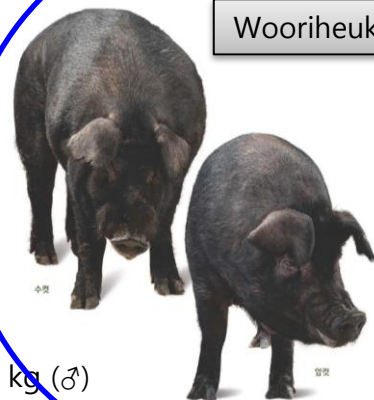
Color: black
Weight: 200-300 kg (♀) 250-300kg (♂)
Height: 85-90cm (♀) 100-105cm (♂)
Number of litters: 9 to 14



Korea Native Pig



Duroc



Wooriheukdon

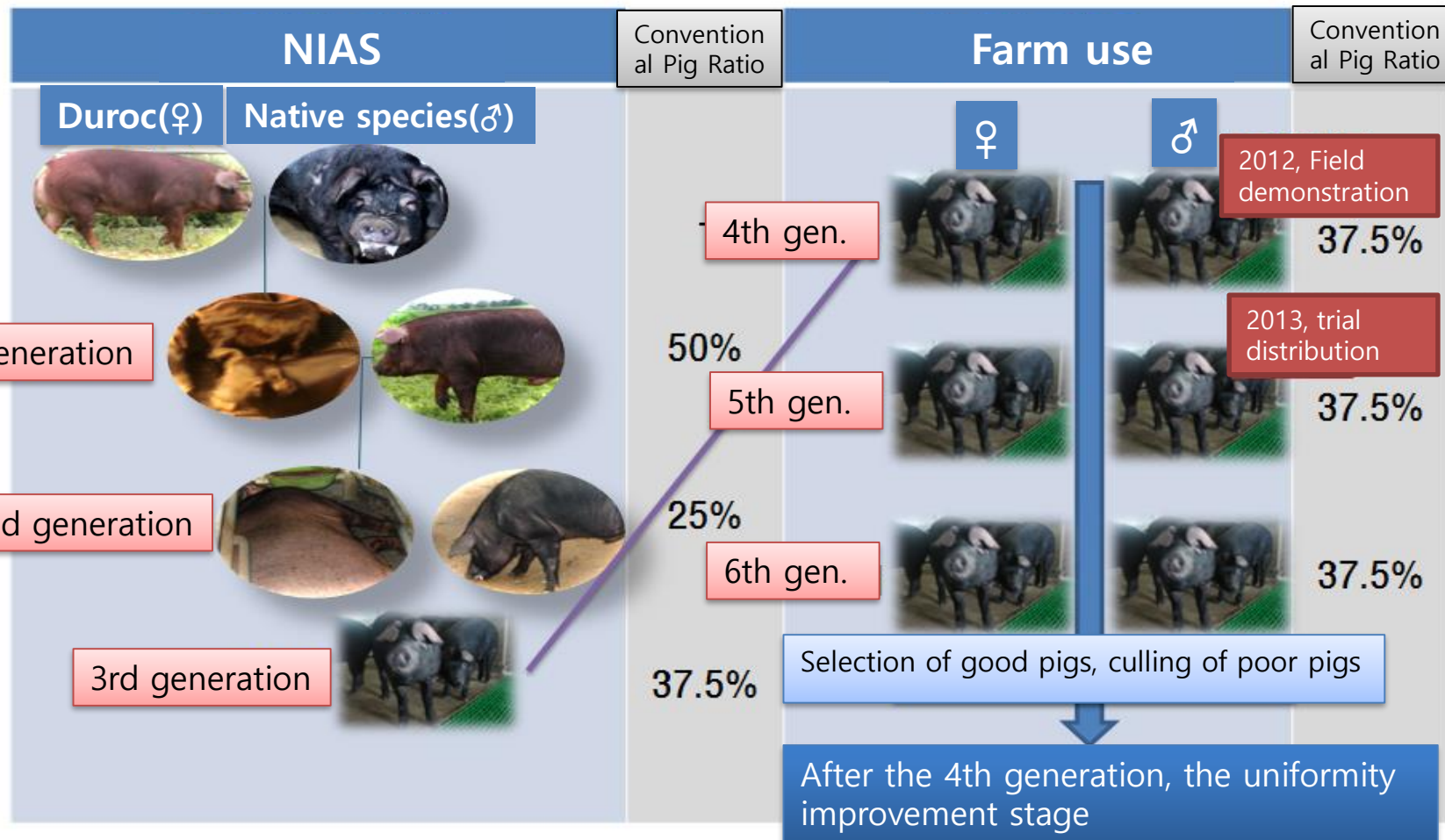
Color: black
Weight: 110-120 kg (♀) 130-150 kg (♂)
Height: 75-80cm (♀) 80-85cm (♂)
Number of litters: 6-8

Color: black
Weight: 200-250 kg (♀) 250-300 kg (♂)
Height: 80~85cm(♀) 95~100cm(♂)
Number of litters: 9 to 10

How is 'Wooriheurdon' made?



- The Wooriheurdon variety was developed by hybridizing the Duroc and the conventional variety.



How is 'Nanchukmacdon' made?

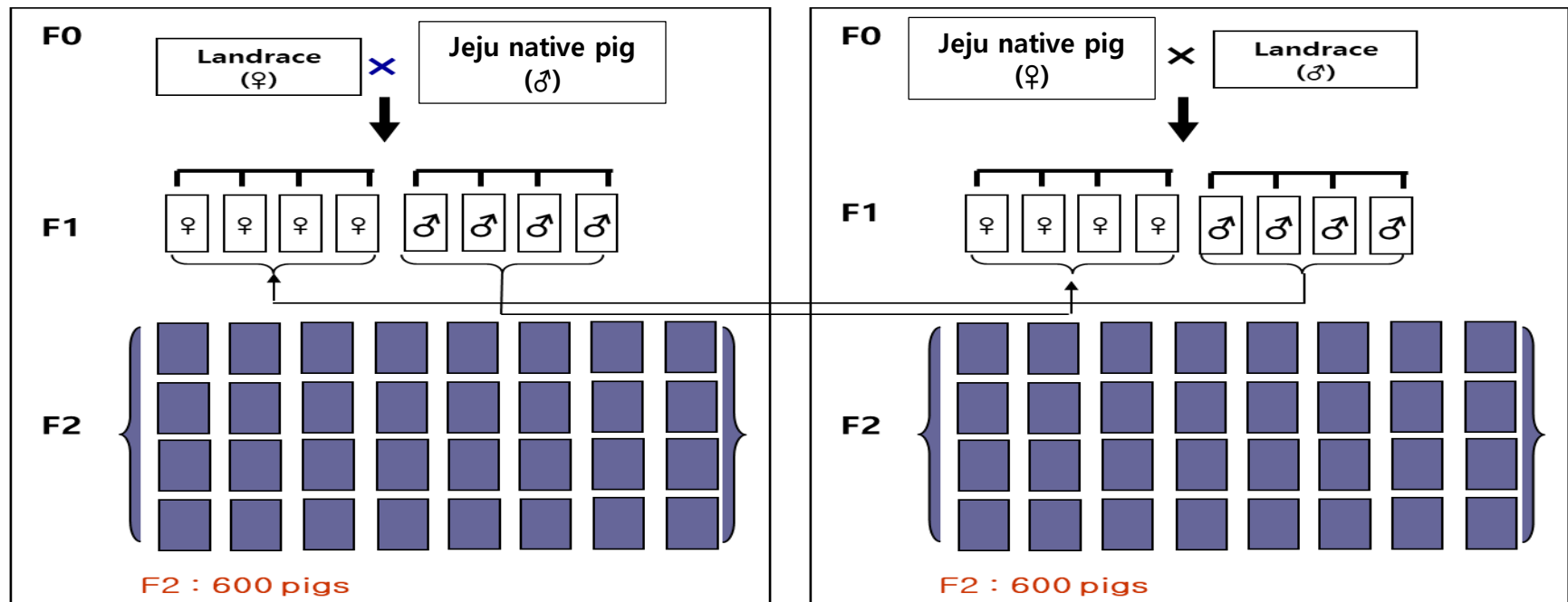
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○ How to construct a reference family

- Crossbreeding: Jeju native pig × Landrace
- Breeding method: reciprocal intercross
- Test cattle group: 1,400 females (F0: 36 heads, F1: 92 heads, F2: 1306 heads)

* Completion of the world's largest reference herd.



< Crossing method to create a reference family >

How is 'Nanchukmacdon' made?

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○ Investigation of phenotypic data from the reference family (1,273 heads)

1. Growth traits: 15 traits including weight by age, number of nipples, number of ribs, etc.
2. Blood type: 8 traits including WBC, RBC, PLT
3. Serotype: 25 traits including GPT, GOT, AMY
4. Meat quality: 30 traits including intramuscular fat content, meat color, fatty acid composition, etc.
5. Analysis of amino acid content in meat: 19 traits
6. Coat color: 6 traits including black, white, roan etc

Number of surveyed heads: 1,273 heads (100 items/per head):

Total about 127,300 related data

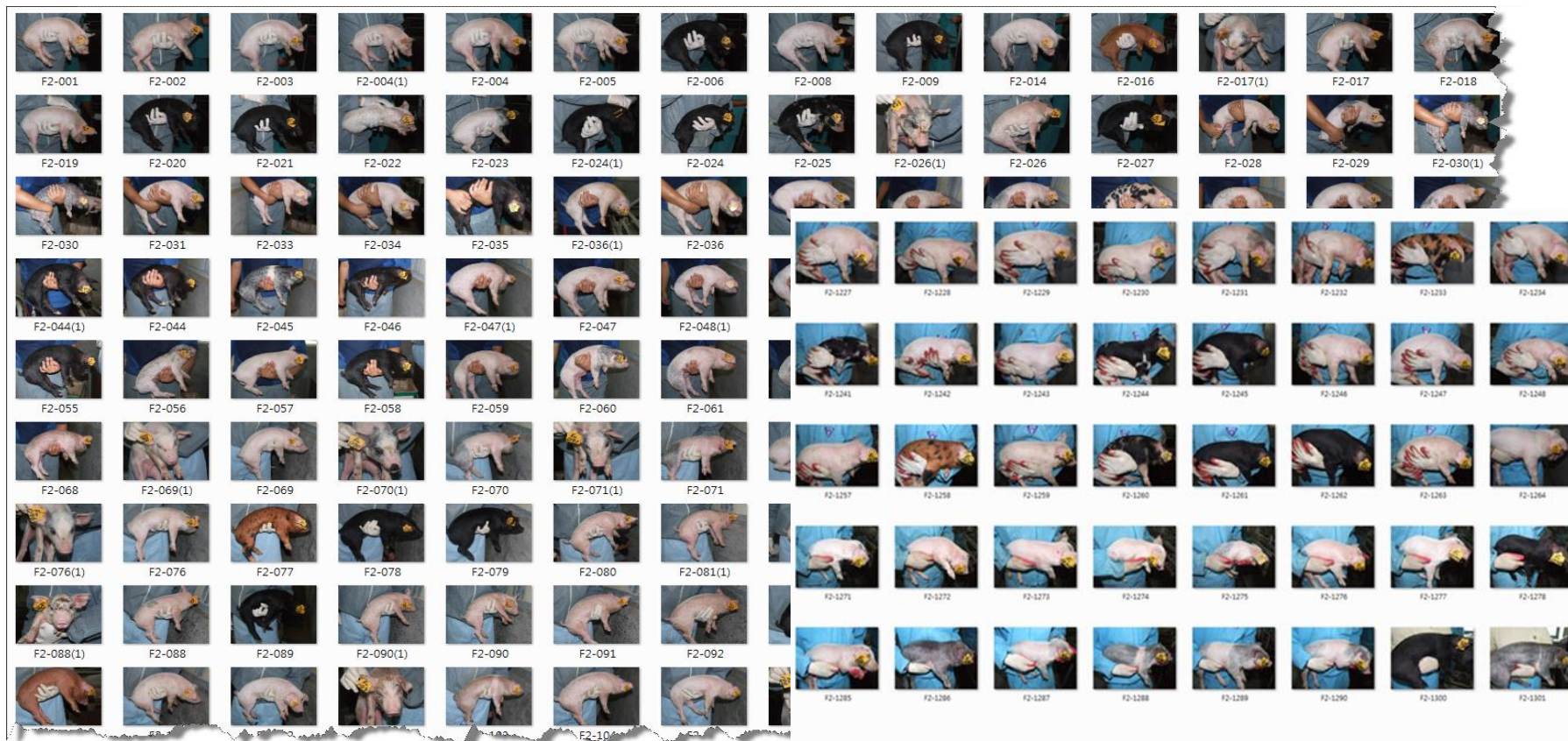
Finding the cause of black hair

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F2 offspring of Jeju native pigs and landrace crossbreeds

- Coat color phenotype of F2 progeny



Finding the cause of black hair

Classification of F2 offspring by color

- Divided into 6 main types



1. white



2. red black



3. roan



4. black

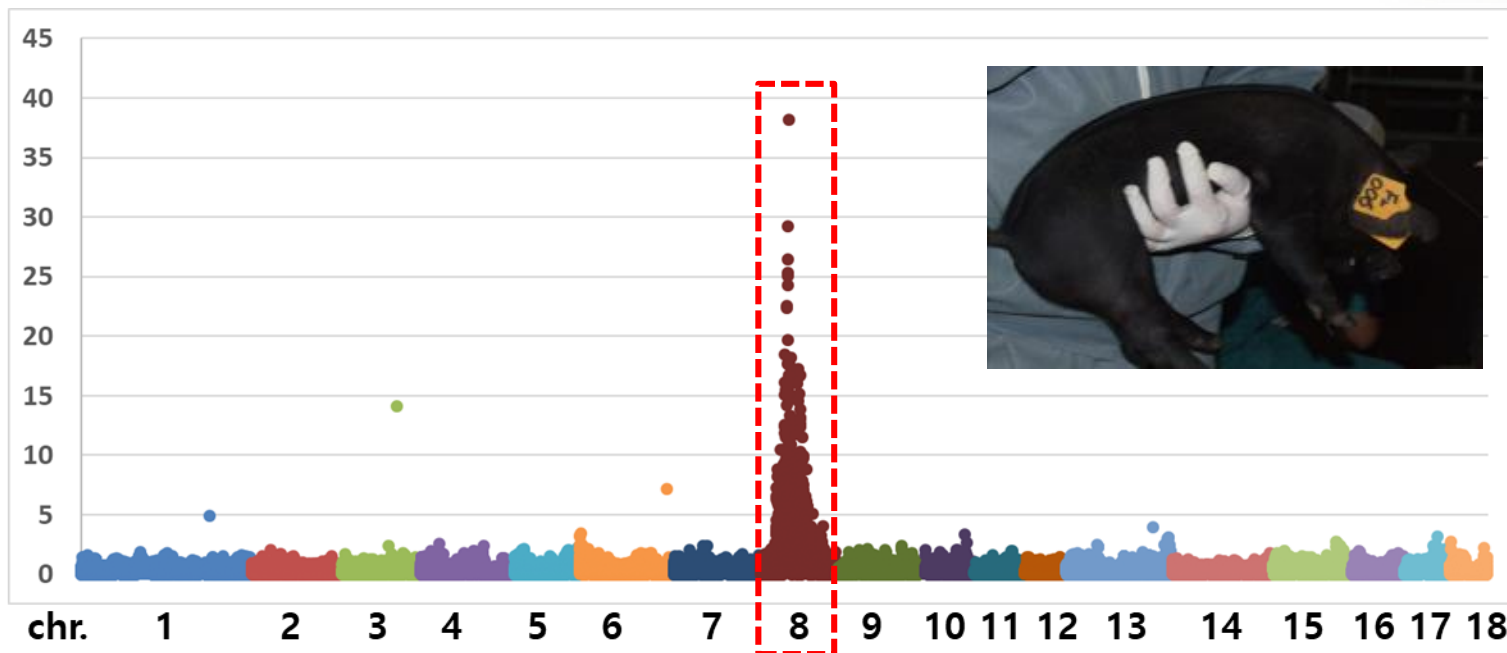


5. spot(black_spot)



6. white_black

Development of source technology (discovery of black pig hair gene)

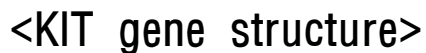


Result of GWAS locus for black coat color in F2 offspring by crossing a white landrace with a native black haired Jeju pig (pig 8-chromosome)

☞ Black hair color is induced by base mutation of exon2 of KIT gene of chromosome 8

* Genetic analysis result: 99.99% exact match

- Development of a key gene for determining black hair



Development of source technology (discovery of genes responsible for meat quality)

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동촌진흥청

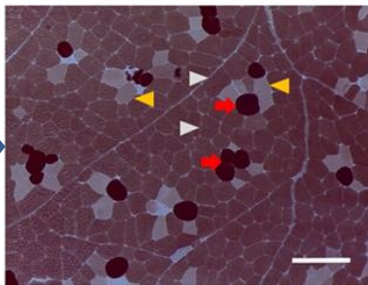
Landrace



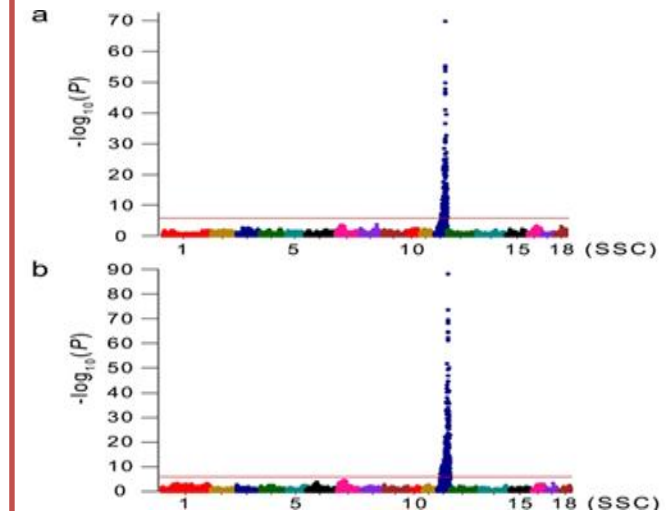
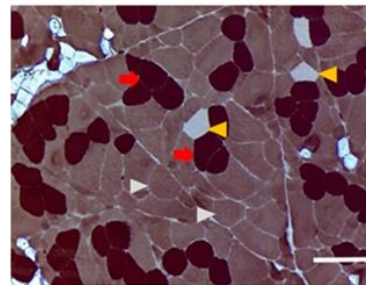
sirloin



muscle fiber
composition



Jeju native pig



The presence of the causative gene on chromosome 12 was confirmed by locus analysis of **meat color (a; redness)** and **intramuscular fat content (b; marbling)**
(*first report in the world)

Difference in 'meat quality'

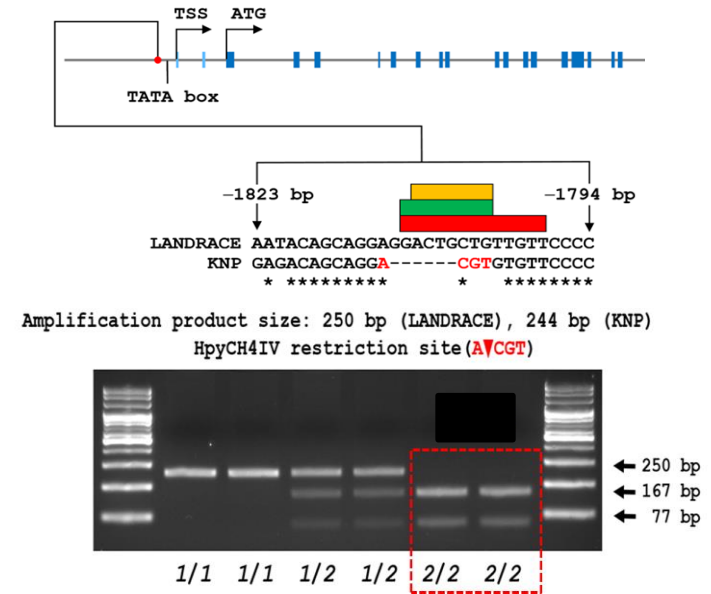
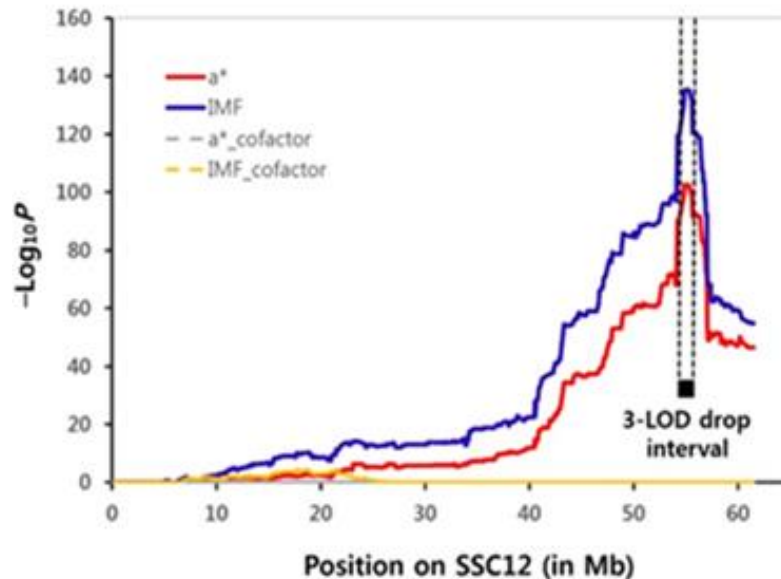
= Difference in 'muscle fiber composition'

= Confirmation of 'causal gene'

Development of source technology (discovery of genes responsible for meat quality)

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Genetic region fine mapping for pork meat quality
(intramuscular fat content, red meat)



- It was confirmed that **6 nucleotide sequence deletions** in the transcription region of the **MYH gene** on **chromosome 12** were the cause.
- Development of a diagnostic method to select new piglets with good meat quality

Meat quality gene frequency by pig breed

Breed		n	$p(Q)$
European wild boar	Polish wild boar	4	0
	Romanian wild boar	4	0
	Swedish wild boar	3	0
	Slovenian wild boar	4	0
	Spanish wild boar	1	0
European domestic pig	Large White	30	0
	Landrace	17	0
	Berkshire	30	0.02
	Hampshire	2	0
	Duroc	30	0
	Iberian	6	0
	United Kingdom Middle White	1	1
	United Kingdom Large Black	2	0
	United Kingdom Saddle Back	2	0
	United Kingdom Old Spot	1	0
	United Kingdom British Lop	1	0
	United Kingdom Chester White	4	0
African wild boar	Tunisian wild boar	6	0
	Moroccan wild boar	1	0
Asian wild boar	Korean wild boar	90	0.13
	Russian wild boar (Primorsky Krai)	9	0.22
Asian domestic pig	Korean native (Jeju)	51	0.63
	Chinese Jinhua	6	0.08
	Chinese Min	7	0.21
	Chinese Neijiang	5	0.80
	Chinese Putian	5	0.80
	Chinese Tongcheng	10	0.90
	Chinese Wannanhua	5	0.00
	Chinese Wuzhishan	17	0.00
	Chinese Xiang	23	0.54

Development of source technology (discovery of genes responsible for meat quality)

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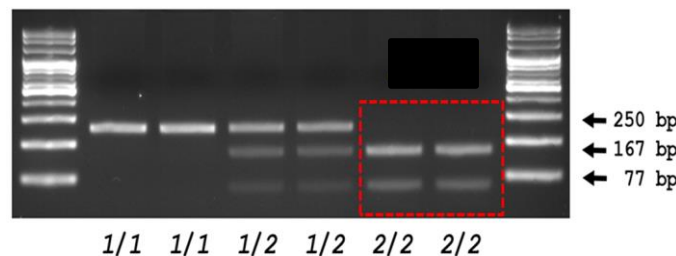
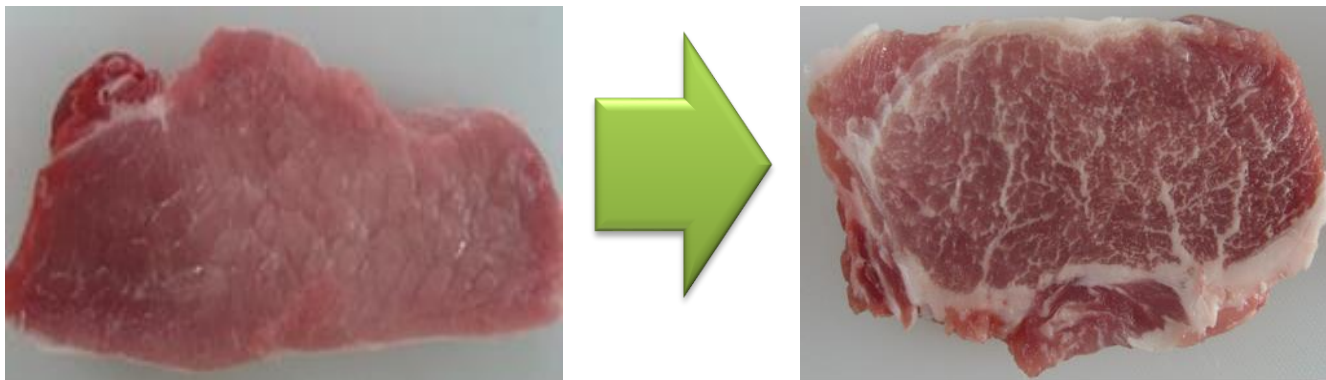
동촌진흥청

Effects of meat quality improvement when the meat quality gene is applied to a group of pigs

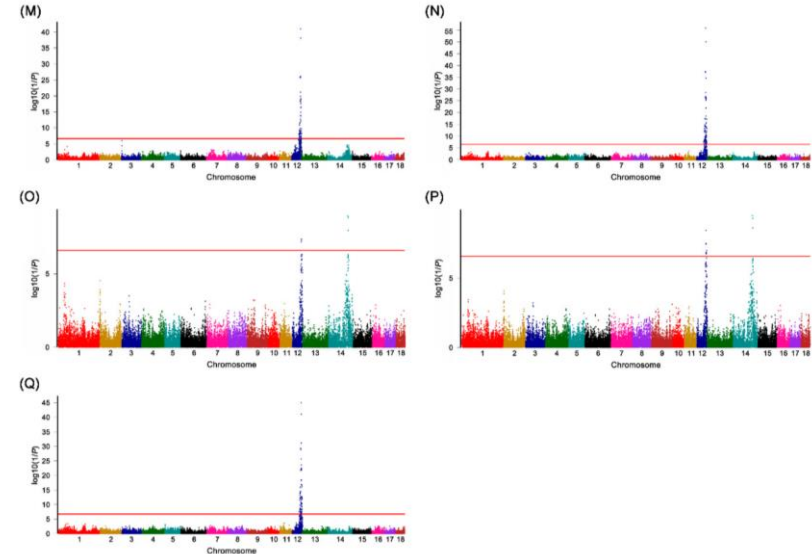
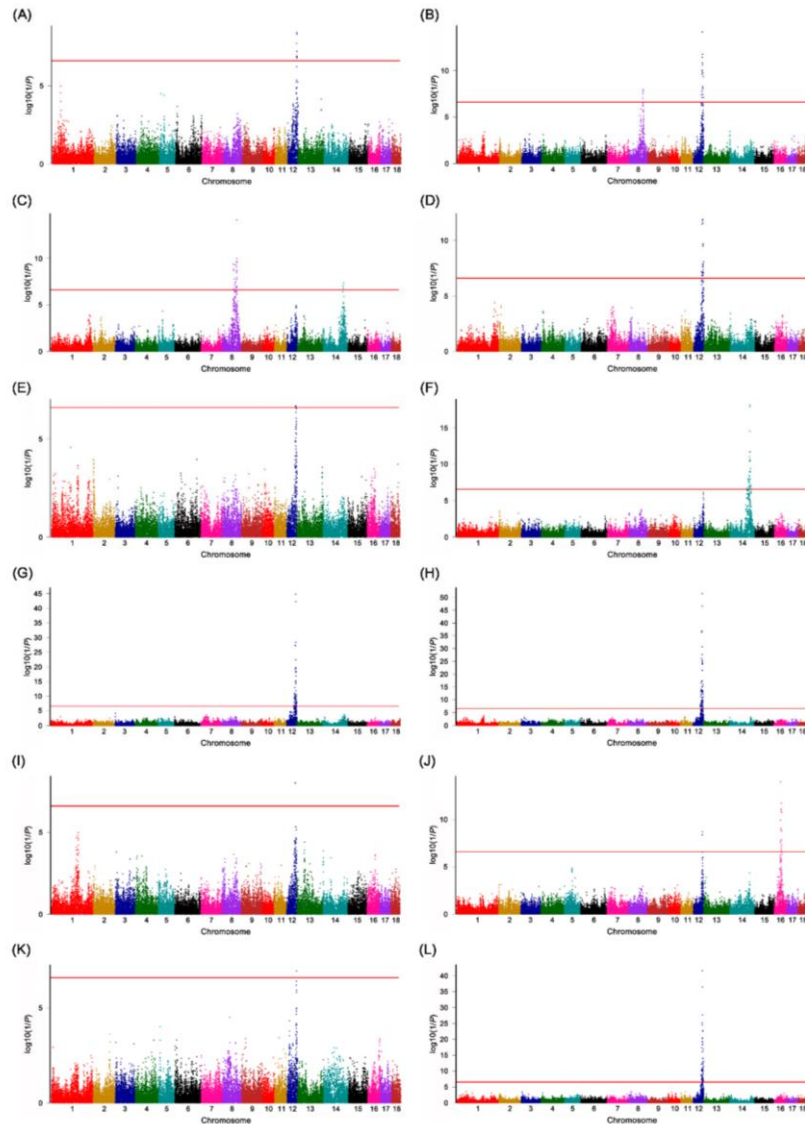
■ Development of a key meat quality gene that determines the taste of meat

- Intramuscular fat content (marbling), redness, etc. Gene selection and application system development

☞ **More than 400% improvement** in meat quality compared to regular pigs



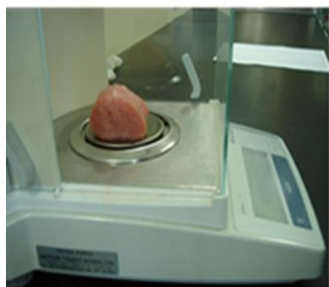
Types of fatty acids determined by pig 12-chromosome



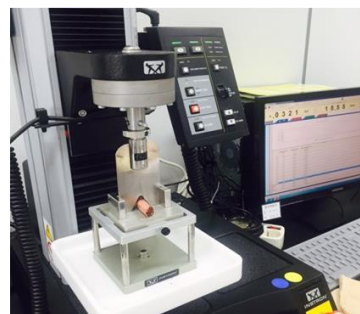
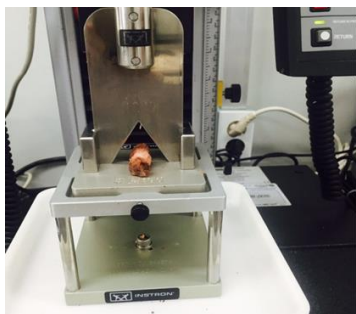
Manhattan plots of the GWAS for the fatty acid composition traits in the LK cross. The y-axis shows the $-\log_{10}(p\text{-value})$, and the x-axis shows the genomic map positions of the SNP markers on the pig autosomes. The genome-wide significance threshold value is 6.60, which equals a Bonferroni correction of 1% (represented by the red horizontal lines).

(A) Manhattan plot for C12:0; (B) Manhattan plot for C16:0; (C) Manhattan plot for C16:1; (D) Manhattan plot for C17:0; (E) Manhattan plot for C17:1; (F) Manhattan plot for C18:0; (G) Manhattan plot for C18:1; (H) Manhattan plot for C18:2; (I) Manhattan plot for C18:3; (J) Manhattan plot for C20:0; (K) Manhattan plot for C20:1; (L) Manhattan plot for C20:4; (M) Manhattan plot for MUFAs; (N) Manhattan plot for PUFA; (O) Manhattan plot for SFA; (P) Manhattan plot for UFA; (Q) Manhattan plot for P/S ratio. The Manhattan plots show the identification of the major QTL for FA profile traits in SSC12.

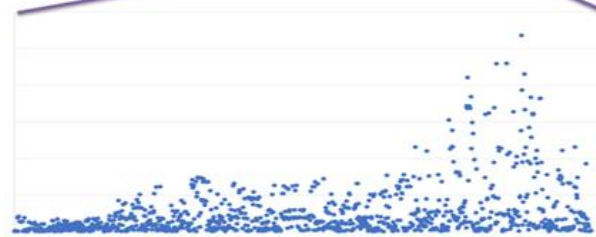
Genetic loci for water holding capacity and shear force in pork



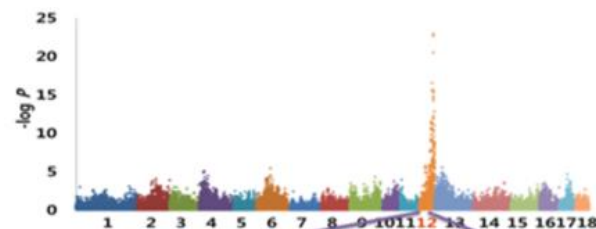
Breed (No)	Moisture content	Drip loss
Landrace (47)	74.23±0.65	4.18±2.51
JNP (21)	72.43±2.31	0.99±0.62



Breed	Number of analysis	Shear force
Landrace	47	4.48±0.89
Jeju Native Pig	21	2.93±1.02



water holding



shear force

The excellence of "Nanchukmacdon"



■ The world's first molecular breeding livestock

- The world's best meat quality (marbling, meat color, taste, etc.)
- Meat quality and black hair color are completely fixed at the genetic level



<Nanchukmacdon>



<Sirloin of Nanchukmacdon>



<common pork loin>

■ Intramuscular fat content more than 4 times (2.58% vs. 12.65% of Nanchukmacdon)

- The entire area can be used for roasting by strengthening the deposition of fat in the low-fat area.

■ Meat color (redness): Intermediate of red meat between beef and pork (CIE a: 6.5 → 12.35)

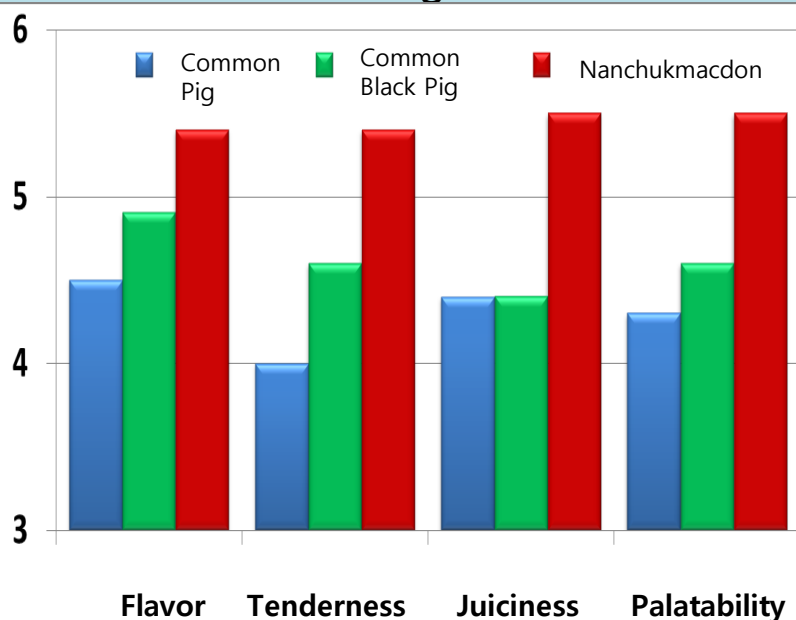
Consumer preference evaluation result



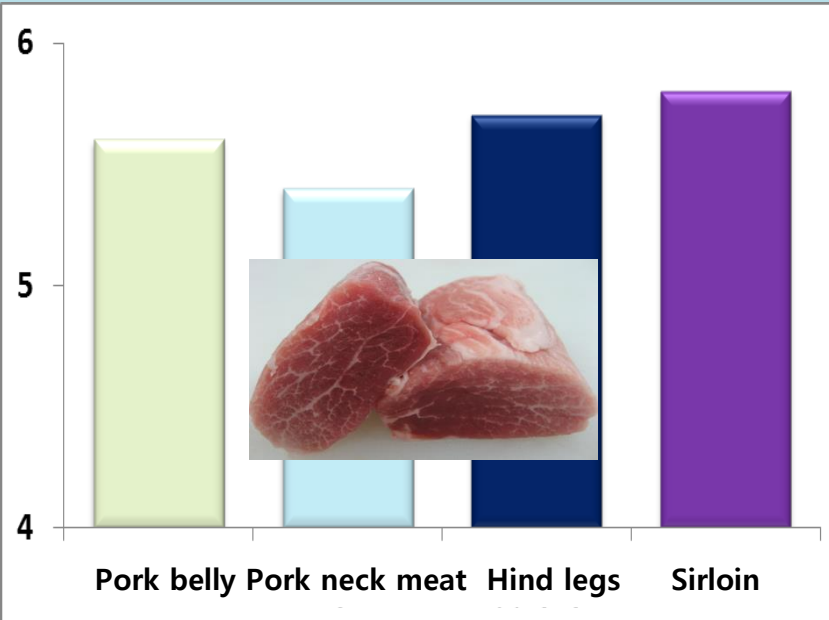
Outstanding in **flavor, tenderness, juiciness and palatability**

- Comparison Breeds: Common Pig, Imported Black Pig and Nanchukmacdon
- Evaluation part: pork belly, sirloin, hind leg meat

In consumer comparative evaluation of each part of meat, the whole part can be used as grilled



Taste evaluation by pig breed
(average value of 3 parts)

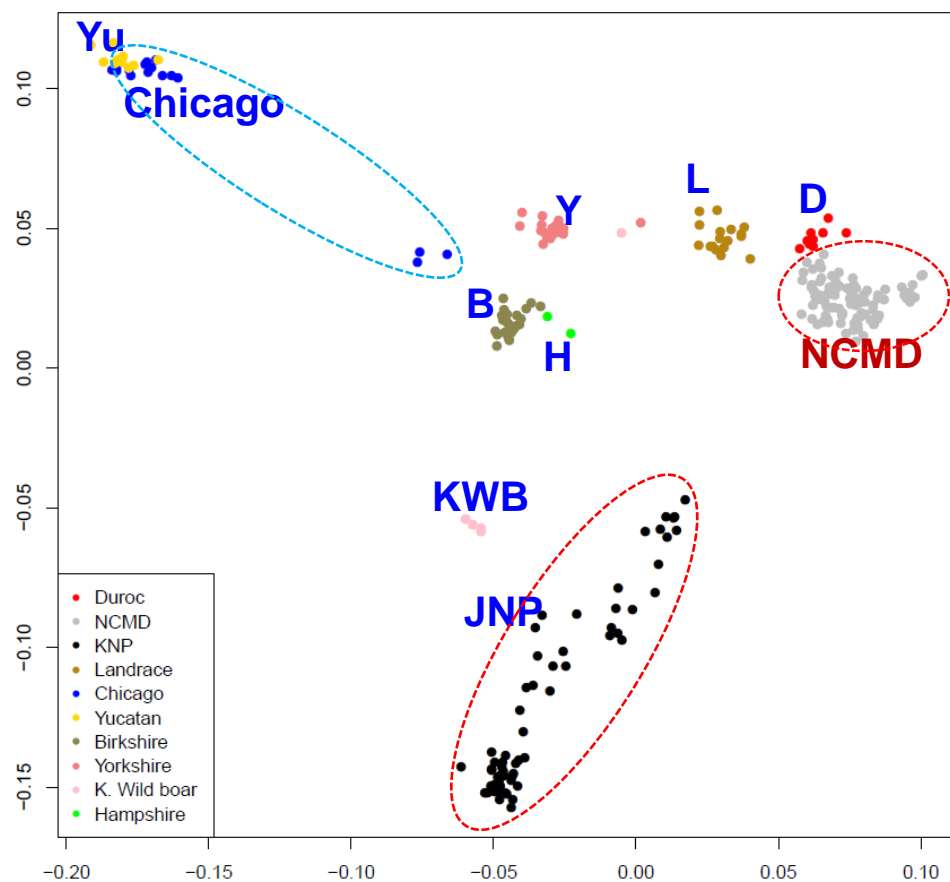


Nanchukmacdon taste
evaluation by part

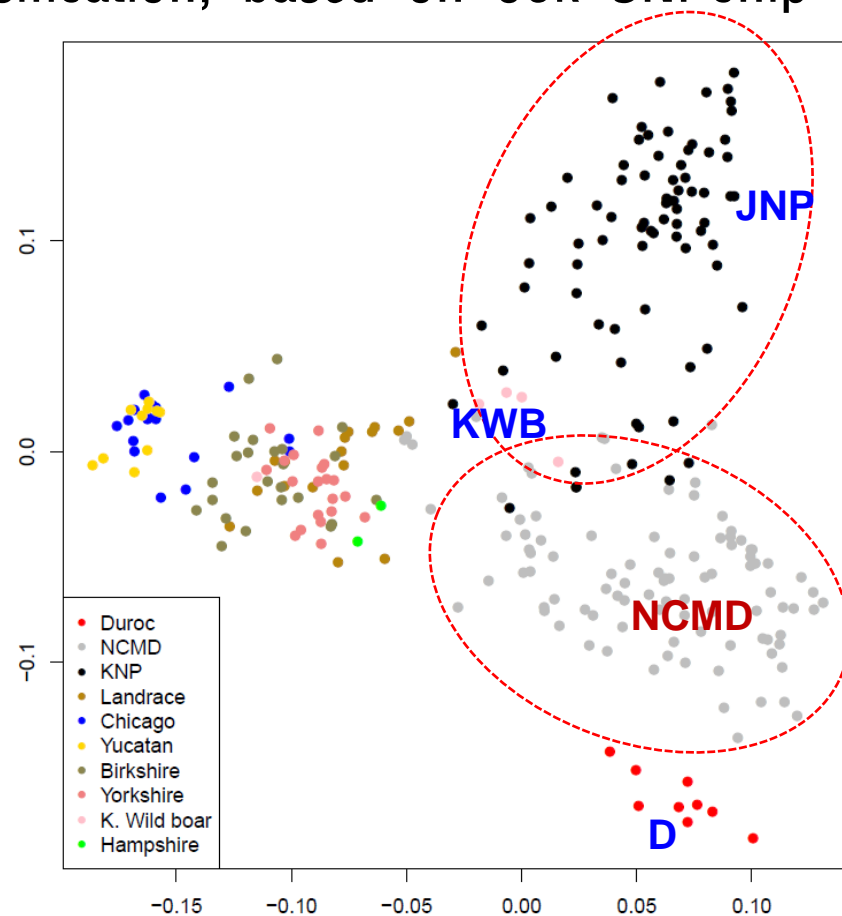
PCA analysis between pig breeds



□ Nanchukmacdon phylogenetic classification, based on 60k SNPchip



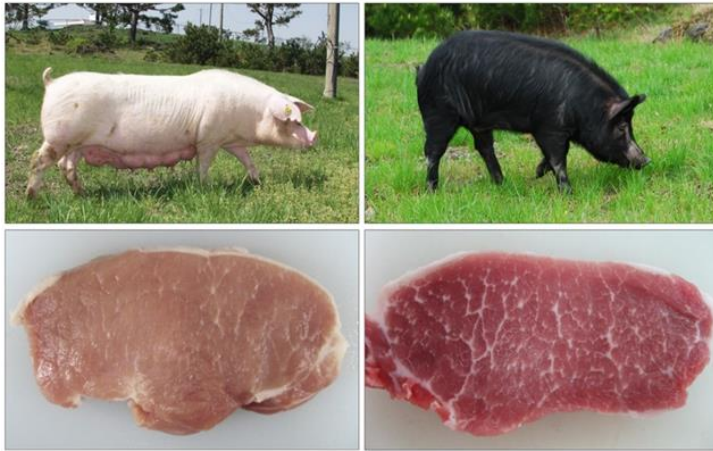
< Full-length chromosome analysis >



< 12-chromosome analysis >

Current level of 'Nanchukmacdon'

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<Landrace>

<Jeju native pig>



<Sirloin of Nanchukmacdon>



<Common pork loin>

- ✓ Blood ratio of native pigs: 5% or less (50% at the time of development in 2013)
 - At the time of development: There is a lot of variation between individuals (growth, nipple shape, back fat thickness, etc.)
- ✓ Current level
 - ❖ Number of births: Average of **11.2 or more**
 - ❖ 140 days old weight: ('13)75 -> ('20)85kg -> ('22) **90kg or more**
 - ❖ Back fat thickness: ('13) 30mm or more -> ('19) **18.88mm**

Production of 5k SNPchip associated with pig phenotype

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RDA
농촌진흥청

□ Production of pig phenotype-related gene industrialization products

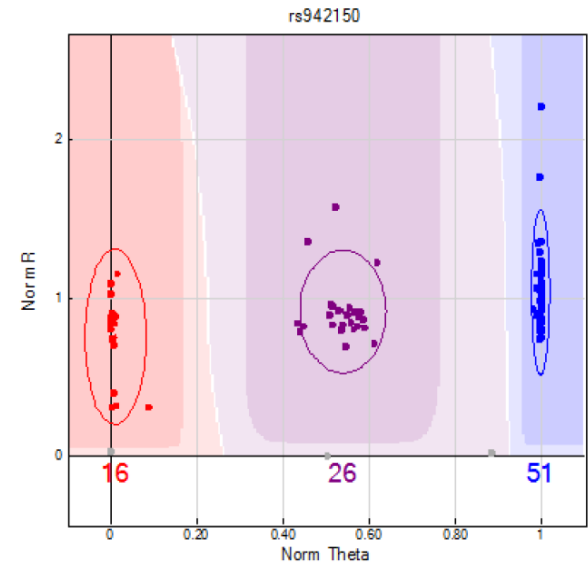


Clustering Algorithm

- Determines location and shape of each genotype cluster

Calling Algorithm

- Determines which genotype bin each data point belongs to



< SNP extraction from NGS data >

< Pig phenotype >

(Meat quality) IMF, CIE a, b, c, shear force, drip-loss, fatty acid composition, SCD, etc.

(Meat) EMA, thoracic

(Hair color) black, white, coarse color, etc.

(Others) More than 50 traits such as AMY, GGT, number of nipples, thickness of back fat

Breeding history of Jeju native black pigs

- (1325) Pig breeding was active after the promotion of livestock production by King Chung Suk at the end of the Goryeo period.
- (1861) In the **Joseon Dynasty Daedongyeojido**, the places where horses, cattle, and pigs are raised are indicated in Jeju City, indicating that black pigs are bred under the control of the state.
- (1940s) In the 1940s, the number of native pigs decreased sharply due to the introduction of high-quality Berkshire-like breeds.



Daedongyeojido
大東輿地圖(1861)



Sundae



Soup made with
gulfweed in broth



Dombe meat



Meat noodles



Roast pork

Acknowledgement

In-Cheol Cho, Moon-Cheol Shin, Hyeon-Ah Kim, Ji-Hyun Yoo,
Yong-Jun Kang, Sang-Geum Kim and Su-Yeon Kim

