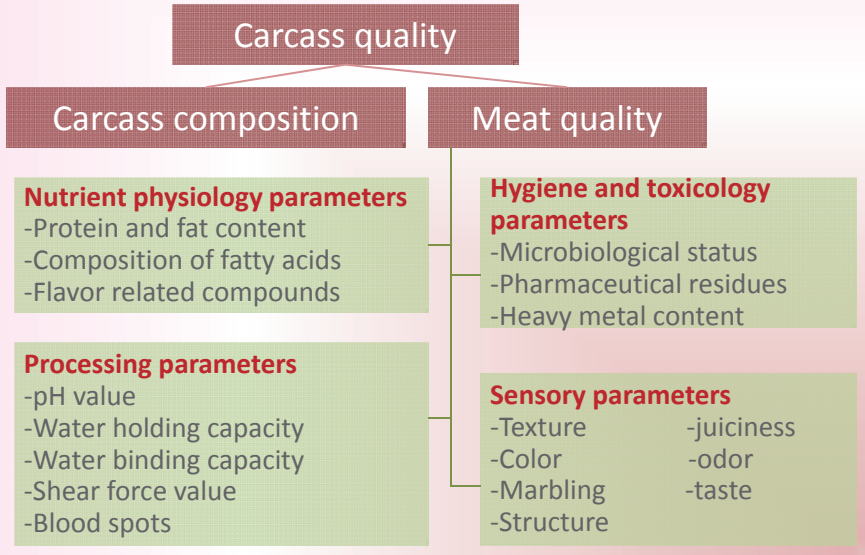
台灣現有豬隻屠體及肉質評估之概況
Overview of current carcass and meat quality evaluation in Taiwan

涂榮珍 副研究員
Tu Rung-Jen, Associate researcher

Outline 大綱

- What is carcass and meat quality?
  何謂屠體及肉品品質?
- Carcass characteristics and evaluation
  屠體特性評估
- Meat quality evaluation in LRI
  畜試所常用之肉品品質評估方法
- Studies on the carcass and meat quality in Taiwan
  台灣屠體與肉品品質研究
- Conclusion
  結論

What is carcass & meat quatlity?



(Hartung *et al.*, 2009)

Outline 大綱

- What is carcass and meat quality?
- Carcass characteristics and evaluation
  屠體性狀評估
- Meat quality evaluation in LRI
- Studies on the carcass and meat quality in Taiwan
- Conclusion

Carcass characteristics and evaluation

- ✓ Carcass side length
  半邊屠體長度
- ✓ Average of fat thickness over lst rib, last rib and last lumbar vertebra
  平均背脂厚度為第一肋、最後一肋及最後腰椎的背脂厚度平均值
- ✓ Loin Muscle Area (loin-eye area)
  腰眼面積

5

- ✓ Peeling 去皮
- ✓ Cutting 分切
- ✓ Weighting 秤重

6

Outline 大綱

- ➢ What is carcass and meat quality?
- ➢ Carcass characteristics and evaluation
- ➢ Meat quality evaluation 肉品品質評估
  1. Water holding and water binding capacity
     保水性及結合水的能力
  2. Analysis of fresh pork color, firmness and marbling
     生鮮豬肉肉色、堅實度及肌間脂肪程度之評分
  3. Physical-chemistry properties
     物理化學特性
  4. Sensory evaluation
     感官品評
- ➢ Studies on the carcass and meat quality in Taiwan
- ➢ Conclusion

Livestock Research Institute

7

Water holding capacity (WHC) : the ability of muscle to hold on to water inherently associated with the post-rigor muscle. In determining WHC of pork, the post mortem rate of pH fall and changes of electrical conductivity are very important factors.

肉的保水性是指解僵後肌肉保有水的能力，肌肉pH值下降的速度與電導度的改變是影響保水性的重要因素。

Water binding capacity (WBC) : the ability of the muscle proteins to hold on to added water form external sources.

肉結合水的能力是指肌肉蛋白質保留或抓住額外添加水的能力。

8

Drip loss & cooking loss
滴液損失率 (滴失率)及蒸煮失重

- ✓ Drip loss is associated with the firmness and WHC of the meat. 滴失率與肉的堅實度及保水性有密切關聯。
- ✓ Not only a high drip loss unattractive, it can result in excessive cooking loss and drying of meat during cooking.
  滴失率高的肉不僅不討喜，而且會造成蒸煮後失重大且肉質乾柴。



9

✓ Methods of water holding capacity (WHC) evaluation 保水性檢測方法

1. Filter paper press method (Ockerman, 1972)
   濾紙加壓法
2. 48-hr drip loss test (Honikel, 1987)
   48小時滴失率檢測法
3. Centrifugation method (Bouton *et al.,* 1971)
   離心法
4. Chen *et al.* (2001) showed the effectiveness of the three methods for determining the WHC of pork, which came from PSE, normal and DFD meat. (J. Agri. Asso. China. 4: 371-376.)
   陳等 (2001)研究指出應用上述3種方法可檢測水樣肉、正常肉及暗乾肉之保水性

10

Table 1. Water holding capacity of different pork categories and methods

Methods	Pork categories		
	PSE	Normal	DFD
Filter paper press, %	68.5 ± 7.7[a]	66.4 ± 6.8[a]	53.4 ± 5.1[b]
Centrifugation, %	76.2 ± 7.3[a]	71.9 ± 7.8[a]	60.9 ± 6.4[b]
Drip loss, %	6.1 ± 0.5[a]	5.6 ± 0.6[a]	1.0 ± 0.1[b]

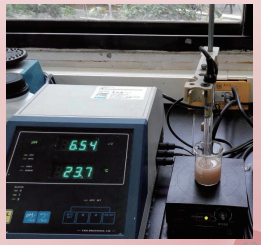
Means ± standard deviation
[a, b] Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Chen *et al.,* 2001. J. Agri. Asso. China. 4: 371-376.)

11

✓ Water binding capacity (WBC)

1. The best indicator for WBC would be measurement of meat pH.
2. The term pH is used frequently in our industry today.
3. pH is highly correlated to the quality traits of color and water holding capacity as well as various eating quality traits, such as tenderness.

12

2. Analysis of fresh pork color, firmness and marbling

生鮮豬肉肉色、堅實度及肌間脂肪程度之評分

Followed by the guideline of National Pork Producers Council (1991).

13

3. Physical-chemistry properties 物理化學特性

Hunter L, a, b values :

The L value is a measurement for brightness **(亮度值);**

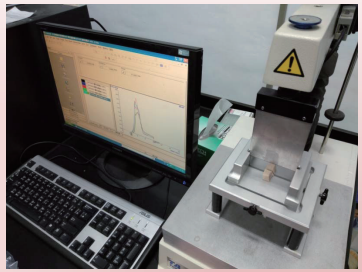
The a value displays the color range from **green** to **red (紅色度值);**

The b value is a scale unit for the color range from **blue** to **yellow (黃色度值).**

14

- **Shear value**: meat-solidity is a quality characteristic of importance for meat processing. It is measured by meat texture (e.g. shear force or compression force), which affects the performance at distortion.

80℃ for 40 min



截切值通常以固定的蒸煮方式及切片大小，以物性測定儀進行檢測，其檢測值代表肉的質地或硬度，模擬以口咬斷所需的力量；其值小代表愈軟嫩，大代表愈堅韌。

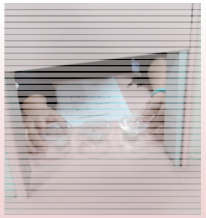
15

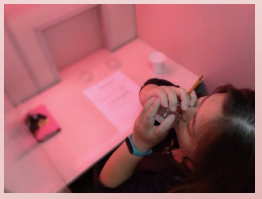
4. Sensory evaluation 感官品評

The sensory assessment depends on three principal considerations.

感官品評主要評價三個面向:

1. Appearance characteristics
   外觀特性
2. Textural characteristics
   組織咬感
3. Flavor factors
   風味





16

Outline

- What is carcass and meat quality?
- Carcass characteristics and evaluation
- Meat quality evaluation
- Studies on the carcass and meat quality in Taiwan 台灣屠體與肉品品質研究
- Conclusion

Breed difference
品種差異

Table 2. Breed differences for carcass measures in boars

Item	Breed			
	Berkshire	Landrace	Yorkshire	Duroc
No. of pigs tested	30	42	36	29
Carcass weight, kg	81.6 ± 2.0^{c}	100.6 ± 1.5^{a}	102.4 ± 1.6^{a}	96.0 ± 1.6^{b}
Carcass length, cm	77.7 ± 1.0^{c}	91.6 ± 0.8^{a}	87.8 ± 0.8^{b}	86.2 ± 0.9^{b}
Backfat thickness, cm	2.6 ± 0.1^{c}	2.0 ± 0.1^{a}	2.3 ± 0.1^{b}	2.1 ± 0.1^{a}
Abdominal fat thickness, cm	3.8 ± 0.1^{a}	3.7 ± 0.1^{a}	3.5 ± 0.5^{ab}	3.5 ± 0.1^{b}
Loin muscle area, cm^2	34.3 ± 1.3^{c}	46.0 ± 0.9^{a}	45.9 ± 1.0^{a}	43.0 ± 1.0^{b}
Lean percentage, %	52.4 ± 0.6^{c}	58.4 ± 0.4^{a}	57.2 ± 0.5^{b}	57.7 ± 0.5^{ab}

Means ± SE

$^{a, b, c}$ Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Lai *et al.,* 2003. Taiwan Livestock Res. 36(2))

Table 3. Breed differences for carcass measures in gilts

Item	Breed			
	Berkshire	Landrace	Yorkshire	Duroc
No. of pigs tested	50	81	72	62
Carcass weight, kg	82.4 ± 1.7^{b}	88.5 ± 1.1^{a}	87.3 ± 1.1^{a}	89.3 ± 1.2^{a}
Carcass length, cm	80.7 ± 0.9^{c}	88.5 ± 0.6^{a}	84.6 ± 0.6^{b}	83.6 ± 0.6^{b}
Backfat thickness, cm	2.5 ± 0.1^{c}	1.9 ± 0.1^{a}	2.2 ± 0.1^{b}	2.2 ± 0.1^{b}
Belly fat thickness, cm	4.0 ± 0.1^{b}	3.6 ± 0.1^{a}	3.7 ± 0.1^{a}	3.6 ± 0.1^{a}
Loin muscle area, cm^2	39.7 ± 1.1^{c}	42.7 ± 0.7^{a}	41.0 ± 0.7^{ac}	44.6 ± 0.8^{b}
Lean percentage, %	55.1 ± 0.5^{b}	58.7 ± 0.3^{a}	57.9 ± 0.3^{a}	58.1 ± 0.3^{a}

Means ± SE

$^{a, b, c}$ Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Lai *et al.,* 2003. Taiwan Livestock Res. 36(2))

Table 4. Breed differences for pork quality in loin muscle

Item	Breed/Cross*					
	Landrace	Duroc	Berkshire	LD	LB	LYD
No. of pigs tested	7	11	14	9	8	8
Color score	2.1^{c}	2.6^{b}	2.9^{b}	2.6^{b}	2.5^{b}	3.3^{a}
Firmness score	2.4^{b}	3.1^{ab}	3.2^{a}	2.7^{b}	2.9^{ab}	3.2^{a}
Marbling score	1.3^{c}	2.2^{b}	2.3^{b}	2.4^{b}	1.9^{c}	2.9^{a}
Cooking loss (%)	38.2^{a}	35.7^{b}	37.2^{a}	38.3^{a}	35.1^{b}	39.1^{a}
Shear value	7.1^{a}	6.9^{a}	6.9^{a}	6.5^{ab}	5.2^{b}	7.4^{a}

* LD: with L dam and D sire; LB: with L dam and B sire; LYD: commercial hogs.
$^{a, b, c}$ Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Lai *et al.,* 2003. Taiwan Livestock Res. 36(2))

21

Table 5. Sensory panel score of pork belly meat in pigs[1]

Acceptability test	Breed/Cross*					
	Landrace	Duroc	Berkshire	LD	LB	LYD
Sliced appearance	5.2^{ab}	5.3^{ab}	4.9^{b}	5.1^{ab}	5.3^{ab}	5.6^{a}
Fat fragility	4.8^{b}	5.3^{ab}	4.9^{b}	5.4^{ab}	5.3^{ab}	5.7^{a}
Juiciness	5.1^{a}	5.6^{a}	5.2^{a}	5.4^{a}	5.2^{a}	5.4^{a}
Flavor	4.8^{b}	3.4^{c}	3.0^{c}	5.8^{b}	4.2^{b}	5.5^{a}

[1] Sensory panel score: 1 for dislike extensively and 7 for like extensively.
* LD: with L dam and D sire; LB: with L dam and B sire; LYD: commercial hogs.
$^{a, b}$ Values in the same column with different superscripts differ significantly ($P < 0.05$).

(Lai *et al.,* 2003. Taiwan Livestock Res. 36(2))

22

Table 6. Comparison of dressing percentage and yield of roast suckling pig from different breeds at body weight 6 kg or 12 kg

Item	6kg			12kg		
	Taoyuan	Meishan	Crossbred	Taoyuan	Meishan	Crossbred
Dressing percentage, %*	74.1^{b}	75.6^{b}	80.9^{a}	75.3^{b}	76.7^{b}	81.2^{a}
Yield, %**	71.3^{a}	64.1^{b}	62.5^{b}	64.5^{b}	66.6^{ab}	62.1^{b}

* Dressing percentage (%): Carcass wt. / body wt. × 100.
** Yield (%): Roast wt. / carcass wt. × 100.
$^{a, b}$ Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Chen *et al.,* 2001. Taiwan Livestock Res. 34(1))

23

Table 7. Chemical composition and meat quality of *Longissimus dorsi* from different breeds

Item	Breed		
	Taoyuan	Meishan	Crossbred
Moisture content, %	76.7^{a}	75.1^{b}	74.7^{b}
Ash, %	1.14	1.16	1.17
Crude fat, %	2.50^{a}	2.70^{a}	1.75^{b}
Crude protein, %	21.3	21.6	21.9
Water holding capacity, %	60.9^{b}	70.9^{a}	60.0^{b}
pH	5.78^{a}	5.69^{a}	5.46^{b}
Hunter L value	42.4^{b}	45.0^{a}	44.5^{a}
Hunter a value	9.20^{a}	8.29^{b}	7.25^{c}
Hunter b value	7.86	7.95	7.76

$^{a, b, c}$ Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Chen *et al.,* 2001. Taiwan Livestock Res. 34(1))

24

Table 8. Color, firmness, marbling scores and sensory evaluation of *Longissimus dorsi* from different breeds

Item	Breed		
	Taoyuan	Meishan	Crossbred
Color score*	2.67^{ab}	2.57^{b}	2.87^{a}
Firmness score**	2.49^{b}	2.41^{b}	2.86^{a}
Marbling socre***	1.41^{c}	2.03^{b}	2.50^{a}
Tenderness	5.58^{a}	5.42^{a}	4.69^{b}
Juiciness	5.15^{a}	5.36^{a}	4.47^{b}
Flavor	4.73	4.82	4.75

* 1, very light; 5, very dark.
** 1, very soft; 5, very firm.
*** 1, trace; 5, abundant.
$^{a, b, c}$ Values in the same row with different superscripts differ significantly ($P < 0.05$).

(Chen *et al.,* 2001. Taiwan Livestock Res. 34(1))

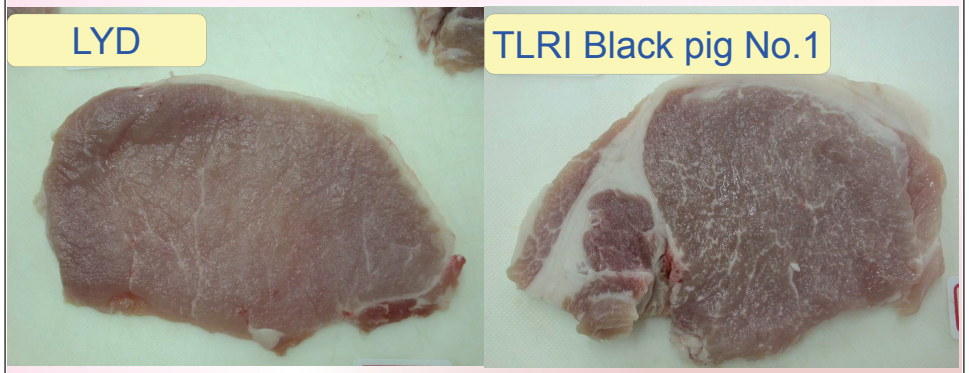
25

TLRI Black pig No. 1
畜試黑豬一號

25% Taoyuan 桃園豬 x 75% Duroc 杜洛克

(http://www.angrin.tlri.gov.tw/)

26



✓ Crude fat content and marbling score of *Longissimus dorsi* from TLRI Black pig No.1 were higher than those from LYD crossbred pig.

畜試黑豬一號里脊肉粗脂肪含量及肌間脂肪評分均高於三品種雜交肉豬。

(Wu, 2013)

27

Table 9. Chemical composition of *Longissimus dorsi* from TLRI Black pig No.1 and LYD crossbred pig

	Source	
Items	TLRI Black pig No.1	LYD crossbred pig
Moisture(%)	72.01^{a}	74.19^{b}
Crude protein(%)	20.08^{a}	21.88^{b}
Crude fat(%)	4.19^{b}	2.99^{a}
Ash(%)	1.63^{a}	1.95^{a}

$^{a, b}$ Values in the same column with different superscripts differ significantly ($P < 0.05$).

(Wu, 2013)

28

Table 11. Fatty acid composition of *Longissimus dorsi* from TLRI Black pig No.1 and LYD crossbred pig

Fatty acid (%)	Source	
		B
C12:0	1.018[a]	1.659[b]
C14:0	3.846[a]	2.301[a]
C16:0	23.128[a]	30.990[b]
C16:1	3.092[a]	4.114[b]
C18:0	12.998[a]	11.726[a]
C18:1	40.242[ab]	42.372[b]
C18:2	14.141[b]	5.650[a]
C18:3	0.572[b]	0.147[a]
C20:1	0.602[a]	0.874[b]
C20:4	0.361[ab]	0.167[a]
SFA	40.990[a]	46.676[b]
MUFA	43.936[ab]	47.360[b]
PUFA	15.074[b]	5.964[a]

[a, b] Values in the same column with different superscripts differ significantly (P < 0.05).

(Wu, 2013)

29

Nutrition

營養

Livestock Research Institute

30

Table 12. Effect of graded levels of feed rice in substitution for corn in diet on the carcass characteristics of KHAPS-Duroc hybrids black pig

Items	Control	Rice replacement ratio, %				SE
		50	75	100	100 + 0.2% Chelated iron	
Slaughter weight, kg	111.60[a]	105.92[b]	107.84[b]	108.11[b]	108.33[b]	0.48
Carcass weight, kg	97.63[a]	92.28[b]	94.05[ab]	94.96[ab]	94.70[ab]	0.53
Dressing percentage, %	87.48	87.13	87.18	87.83	87.41	0.21
Carcass length, cm	82.81	82.19	82.31	83.81	82.25	0.38
Back fat thickness, cm	2.53	2.28	2.55	2.58	2.70	0.07
Lean percentage, %	46.0	45.0	45.1	45.2	44.7	0.46
Fat percentage, %	15.9	15.7	16.0	16.7	17.1	0.47
Bone percentage, %	14.9	15.7	14.6	15.5	14.5	0.21
Loin eye area, cm^2	40.3	37.3	38.2	39.2	39.4	0.95

[a, b] Means with the different superscripts differ significantly (P < 0.05).

(Lee *et al.,* 2017. Taiwan Livestock Res. 50(1))

31

Table 13. Effect of 25% meal or chip of sweet potato to substitute the corn in diets on the carcass characteristics of crossbred finisher pigs

Item	Corn substitute by sweet potato, %; meal or chip			SEM
	Control	25, meal	25, chip	
Carcass weight, kg	84.13	81.52	83.56	2.53
Carcass length, cm	88.15	87.90	88.81	0.74
Backfat thickness, cm	22.84	24.72	25.19	1.13
Loin eye area, cm^2	59.23	54.18	57.51	2.04
Lean percentage, %	58.45	57.82	56.77	0.81
Fat percentage, %	18.41	17.44	19.85	0.74
Bone percentage, %	17.69	17.77	17.86	0.32

(Liao *et al.* 2016. Taiwan Livestock Res. 49(1))

32

Table 14. Effect of 25% meal or chip of sweet potato to substitute the corn in diets on the sensory evaluation of loin meat for pigs

Item	Corn substitute by sweet potato, %; meal or chip			SEM
	Control	25, meal	25, chip	
Flavor	4.47	3.89	4.05	0.16
Juiciness	3.74	3.05	3.89	0.19
Chewiness	4.16^{ab}	4.84^{a}	3.63^{b}	0.15
Overall acceptability	5.28^{a}	4.17^{b}	4.94^{a}	0.15

$^{a, b, c}$ Means in the same row with different superscripts differ significantly ($P < 0.05$).
Scored on a 1-5 point scale (5: very tender, intense or like and 1: very tough, blank and dislike).

(Liao *et al.,* 2016. Taiwan Livestock Res. 49(1))

33

Transportation
運輸

Livestock Research Institute

34

Table 15. Effects of different driving methods on temperature, pH and electric conductivity of carcass

Item	Treatment*			
	A	B	C	D
Temperature$_1$, ℃	31.9	33.6	32.3	32.6
Temperature$_{24}$, ℃	6.1^{b}	4.4^{c}	5.5^{b}	9.0^{a}
pH$_1$	6.33	6.21	6.20	6.31
pH$_{24}$	5.88^{b}	6.02^{a}	5.98^{a}	6.11^{a}
Electric conductivity, mS/cm	5.2^{b}	4.8^{b}	4.8^{b}	6.7^{a}

Temperature$_1$ and Temperature$_{24}$: temperature 45 min and 24 hr post-mortem.
pH$_1$ and pH$_{24}$: pH value 45 min and 24 hr post-mortem.
$^{a, b, c}$ Means in the same row with different superscripts differ significantly ($P < 0.05$).
*A, control (pigs driven by hand); B, driven by wood stick; C, driven by wood board; D, driven by electric goad.

(Chen & Chen, 2001. Taiwan Livestock Res. 34(1))

35

Table 16. Effects of different driving methods on the carcass characteristics of pigs

Item	Treatment*			
	A	B	C	D
Hunter L value	37.4^{c}	39.5^{b}	37.6^{c}	41.5^{a}
Cooking loss, %	35.5^{ab}	35.9^{ab}	34.7^{b}	37.5^{a}
Shear value, kg	5.15^{ab}	4.62^{ab}	5.55^{a}	4.31^{b}
Color score**	3.52	3.12	3.38^{a}	3.15
Free water content, %	2.19^{b}	3.84^{b}	3.14^{b}	4.39^{a}

$^{a, b, c}$ Means in the same row with different superscripts differ significantly ($P < 0.05$).
* A, control (pigs driven by hand); B, driven by wood stick; C, driven by wood board; D, driven by electric goad.
** 1, very pale; 5, very dark.

(Chen & Chen, 2001. Taiwan Livestock Res. 34(1))

36

Conclusion 結論

- In order to separate the domestic and imported fresh meat and keep the good quality of domestic meat product from the market to consumers, the equipment and environment of the supply chain of pork should be improved in Taiwan.

  為了國產生鮮肉與進口肉的市場區隔，溫體肉販售一直是傳統市場肉攤的營運模式。為了保障消費者能購得良好品質的國產豬肉，豬肉供應鏈中的各式設備及處理環境均須進一步地改善。

Improvement of temperature-controlled equipment for carcass transport at slaughter house in Taiwan
台灣肉品市場屠體待運區以溫控車廂取代傳統非控溫運輸車

- Presently, routine methods of measuring meat quality, within a typical Taiwanese meat processing plant, revolve around a few measurements. These include measurements of pH, temperature, microbiological and sulfonamide residue detection.

  目前台灣肉品工廠自主管理僅檢測手續簡便的品質項目，如pH值、肉品溫度及磺胺劑殘留快速檢測等。

- In order to achieve **rapid detection** of defects and to **increase** the **industrial operating efficiency** of products without compromising their quality attributes, non-destructive evaluation and chemical-free assessment method would be necessarily applied to the food industry.

  為了能快速區別肉品品質缺陷並增進工廠操作效能，非破壞性及無化學性的快速檢測肉品品質的技術實有引進的必要。

Livestock Research Institute

The end
Thanks for your attention