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한돈의 소비자 품질 향상을 위한 도축 · 가공 · 유통의 현안 및 연구과제

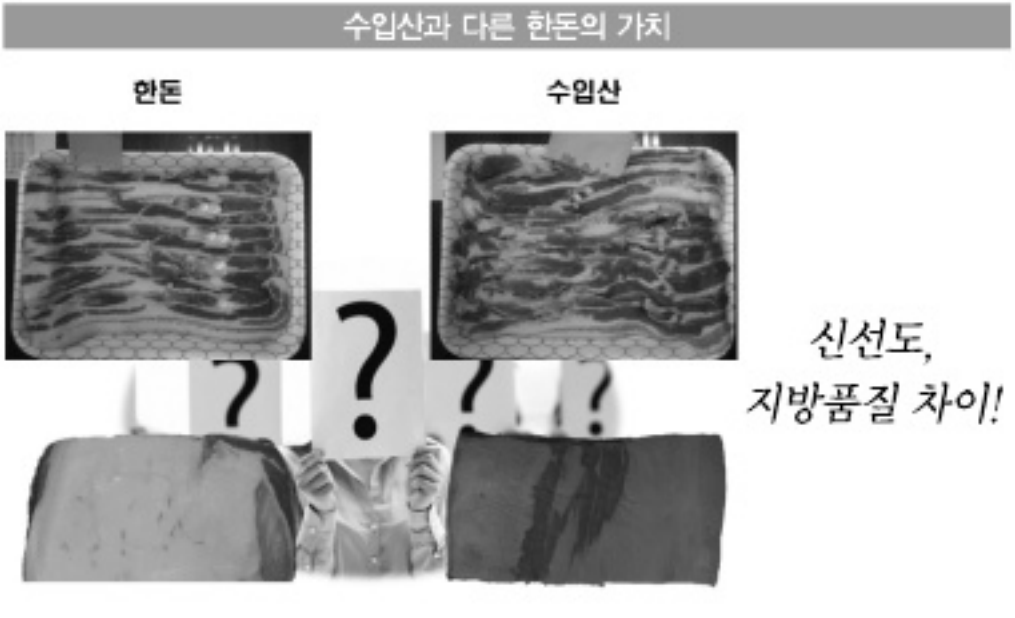


문 성 실 농학박사
㈜선진 Meat&Processing
연구센터장

주요내용

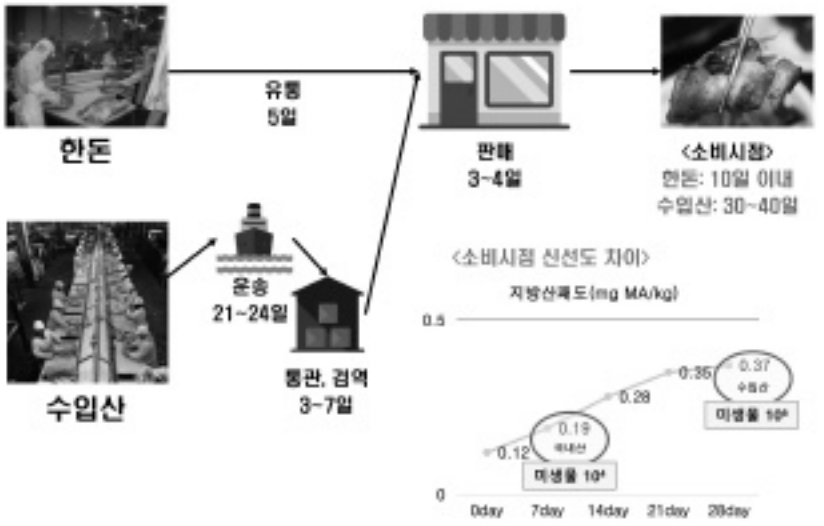
1. 한돈의 가치는 소비자의 Needs에 달려있다
2. 신선도 향상을 위한 연구 동향
3. 돈육의 맛 개선을 위한 연구 동향
4. 육색 및 지방의 특성 개선을 위한 연구 동향

1. 한돈의 가치는 소비자의 Needs에 달려있다



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신선한 한돈

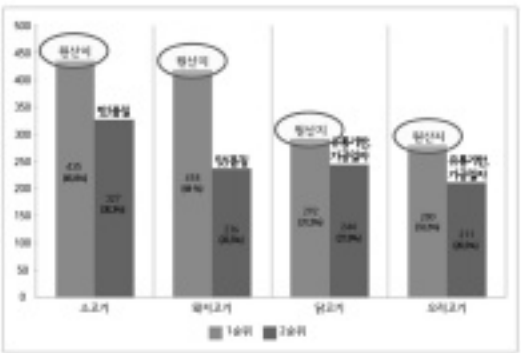


소비자의 니즈가 한돈의 가치를 높인다



고객은
맛있고 안전한 고기를 원한다

국내산 축산물에 대한 소비자의 기대욕구

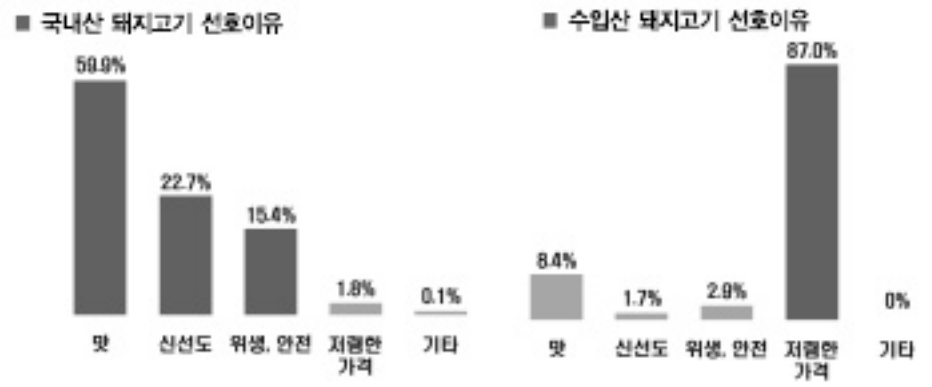


원산지 선호도 1위의 의미는 신뢰!!

출처: 축산물소비형태변화 조사결과 (한국소비자연맹, 2016)

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한돈에 대한 소비자의 기대욕구

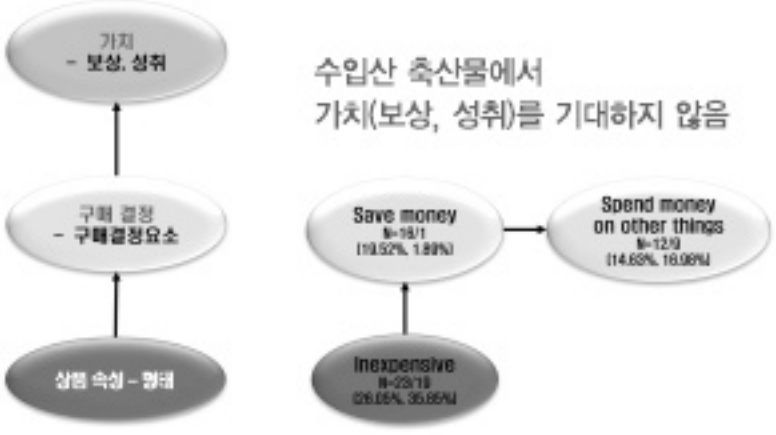


소비자는 한돈에게
맛, 신선도, 위생, 안전을 기대하고 있음

출처: 축산물소비형태변화 조사결과 (한국소비자연맹, 2016)

소비자들이 생각하는 축산물의 가치는?

■ 안전하고 신뢰할 수 있는 축산물 선호
수단-목적 사슬이론에 따른 스웨덴 소비자의 수입산 축산물 구매의사 결정



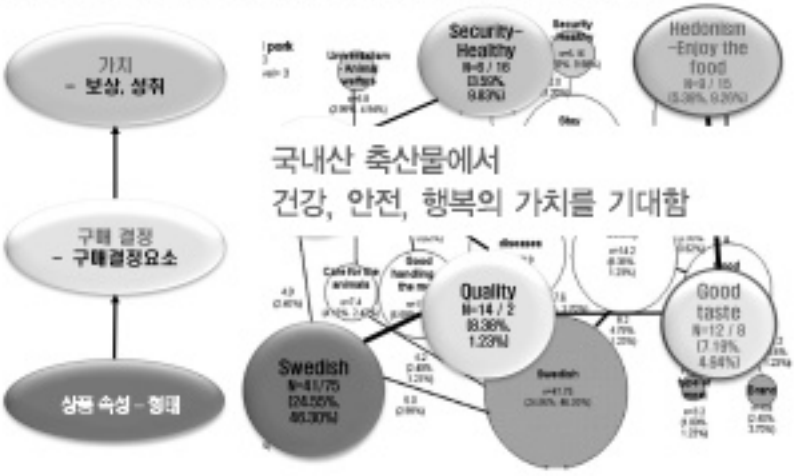
수입산 축산물에서
가치(보상, 성취)를 기대하지 않음

출처: Food Quality and Preference (Lena Westerlund Lind, 2007)

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소비자들이 생각하는 축산물의 가치는?

■ **안전하고 신뢰할 수 있는 축산물 선호**
수단-목적 사슬이론에 따른 스웨덴 소비자의 국내산 축산물 구매의사 결정

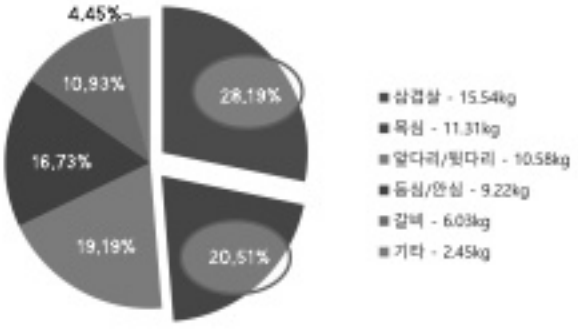


국내산 축산물에서
건강, 안전, 행복의 가치를 기대함

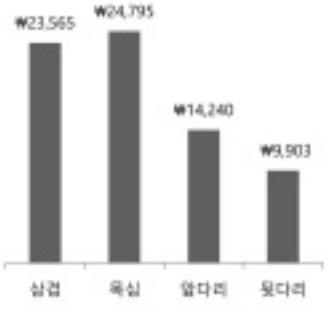
출처: Food Quality and Preference (Lena Westerlund Lind, 2007)

구이에 적합한 돼지고기 부위

■ **돼지고기 부위별 소비량**



■ **2015년 부위별 판매가격**



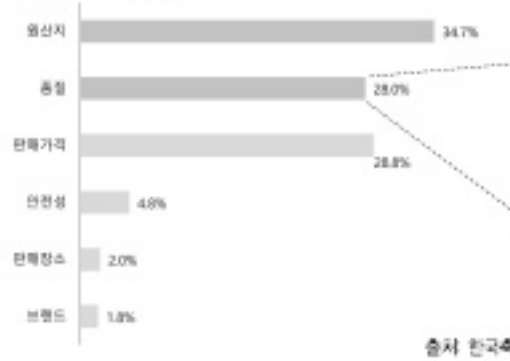
구이에 적합한 삼겹살과 목심의 소비비중이 크고
돼지고기 부위 중 가치가 가장 높다

출처: 2015 축산경영이슈 리포트 (국립축산과학원, 2015), 2017 식육연합

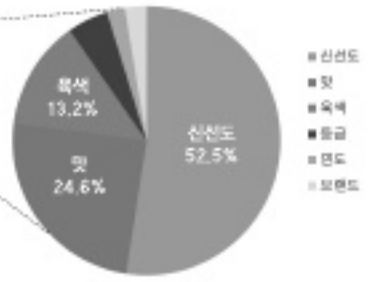
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국내산 육류 구매시 소비자의 고려사항

■ 육류 구입시 가장 중요하게 고려하는 사항 (쇠고기, 돼지고기 돌문)

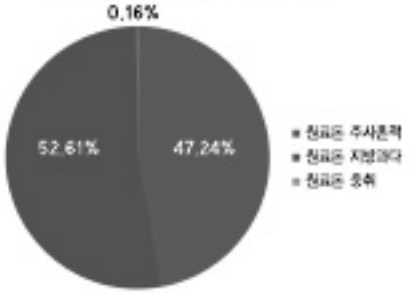


■ 육류 구입시 품질에 대해 고려하는 사항



출처 한국축산경제연구원 육류유통실태조사 (소비자실태조사) 2016년 4분기

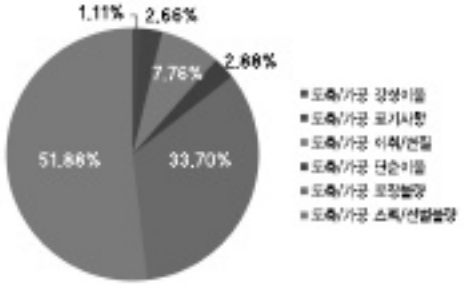
원료돈에 대한 고객불만



지방과다 〉 주사흔적 〉 웅취 순으로 고객불만 발생

출처 선진 식육유통BU 2016년 고객불만보고

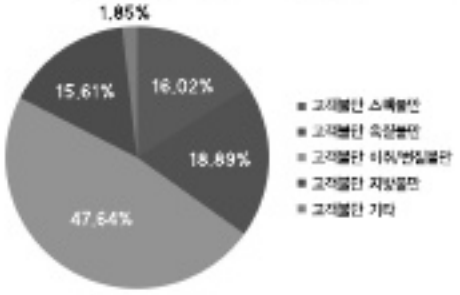
도축/가공에 대한 고객불만



스퀙/선별불량 〉 포장불량 〉 이취/변질 순으로 고객불만 발생

출처 선진 식육유통BU 2016년 고객불만보고

신선육에 대한 고객불만



이취/변질 〉 육질 〉 스퀙 〉 지방 순으로 고객불만 발생

출처 선진 식육유통BU 2016년 고객불만보고

소비자는 어떤 삼겹살과 목심을 원하는가?

신선도 / 맛 / 육색 / 지방의 양 · 질



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2. 신선도 향상을 위한 연구 동향

신선도 개선 연구

■ **Meat Science, 2010**
On-line prediction of fresh pork quality using visible/near-infrared reflectance spectroscopy
Visible / near-infrared (Vis / NIR) 분광기를 이용한 돈육의 품질특성의 예측

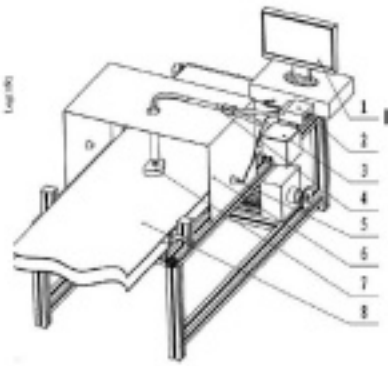
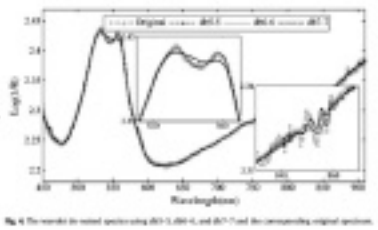


Fig. 1. On-line visible/near-infrared measurement system.



■ First derivative(1st der)과 multiplicative scatter correction(MSC)를 이용하여 파장의 노이즈를 안정화시켜, Partial least-squares regression (PLSR) 모델에 적용, 근내지방, 단백질, 수분, pH, 전단력 값을 예측

■ **Meat Science, 2015**
The effects of blast chilling on pork quality

Chilling conditions
- Blast chilling : 70min, -24°C and then 22h and 50min, 1°C
- Conventional chilling : 24h, 1°C

Traits	Chilling system	
	Blast chilling n = 60	Conventional n = 60
$Temp_{Room}$	19.15 ± 1.33	
$Temp_{0h}$	15.28^{b} ± 4.14	38.23^{a} ± 3.54
$Temp_{3h}$	8.27^{b} ± 1.86	15.17^{a} ± 1.55
$Temp_{24h}$	2.29 ± 0.71	2.51 ± 0.56

Traits (score)	Chilling system	
	Blast chilling n = 60	Conventional n = 60
Color	4.58 ± 0.54	4.64 ± 0.55
Aroma	4.56 ± 0.47	4.67 ± 0.56
Tenderness	3.47^{b} ± 0.83	3.86^{a} ± 0.91
Juiciness	3.78 ± 0.70	3.80 ± 0.86
Flavor	4.67^{a} ± 0.60	4.58^{b} ± 0.63

Traits	Chilling system	
	Blast chilling n = 60	Conventional n = 60
pH_{Room}	6.30 ± 0.21	
pH_{0h}	6.67^{a} ± 0.27	5.84^{b} ± 0.26
pH_{3h}	5.85^{a} ± 0.26	5.73^{b} ± 0.24
pH_{12h}	5.66 ± 0.14	5.61 ± 0.15
pH_{18h}	5.60 ± 0.16	5.57 ± 0.13
pH_{72h}	5.63 ± 0.15	5.63 ± 0.15
pH_{Room}-pH_{72h}	0.67 ± 0.24	0.67 ± 0.26
EC_{0h} (mS/cm)	3.81^{b} ± 1.52	5.13^{a} ± 2.38
EC_{24h} (mS/cm)	5.81 ± 1.80	5.70 ± 2.36

Traits	Chilling system	
	Blast chilling n = 60	Conventional n = 60
Lightness (L*)	55.08^{b} ± 3.38	57.32^{a} ± 3.56
Redness (a*)	6.46 ± 1.23	6.45 ± 1.49
Yellowness (b*)	13.63^{b} ± 1.10	14.46^{a} ± 1.33
Chroma (C*)	15.13^{b} ± 1.29	15.88^{a} ± 1.61
Hue angle (h°)	65.08 ± 4.18	66.18 ± 6.22
Drip $loss_{3d}$ (%)	2.98^{b} ± 1.62	3.72^{a} ± 2.10
Drip $loss_{7d}$ (%)	5.04 ± 2.35	5.68 ± 2.84

1. Blast chilling 온도변화
   - 2시간 이후 도체온도 급강하
2. Blast chilling은 연도와 풍미를 다소 감소시킴
3. Blast chilling의 pH, electrical conductivity 변화
   - conventional과 차이 없음
4. Blast chilling은 육색의 증가와 Drip loss를 감소시킴

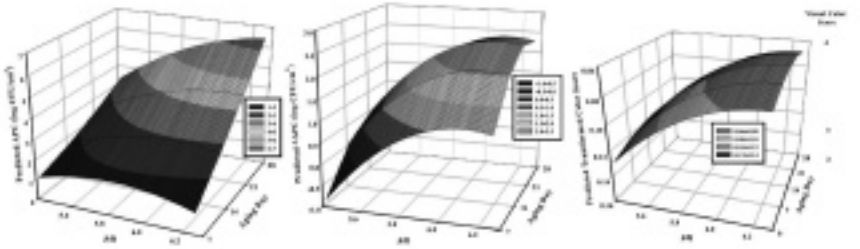
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신선도 예측 모델 연구

■ Meat Science, 2009

The effect of pH on shelf-life of pork during aging and simulated retail display

다양한 pH(5.42-6.26)에 따른 유통기한 예측 회귀방정식 연구



Predicted APC = −105.0832+(0.9071×Aging Day)+(0.0014×Aging Day^2)+(37.5674×pH)−(3.3300×pH^2)+(0.1775×(Aging Day×pH)); R^2 = 0.87

Predicted ΔAPC = −147.6438+(0.2467×Aging Day)−(0.0054×Aging Day^2)+(48.1093×pH)−(3.9279×pH^2); R^2 = 0.52

Predicted transformed color score = 3.05−(0.0014×Aging Day)+(0.00004×Aging Day^2)−(0.9543×pH)+(0.0765×pH^2); R^2 = 0.44

1. 저장기간과 pH를 이용한 APC 회귀방정식의 결정계수는 R^2 = 0.87으로 높음
2. 높은 pH일수록 저장기간이 증가하면 미생물 증식으로 인하여 유통기한이 짧아짐
3. 돈육의 품질과 유통기간을 길게 가져가기 위해서는 중간 pH범위가 적절함

3. 돈육의 맛 개선을 위한 연구 동향

도축 기절 방식이 돈육품질에 미치는 영향

■ Meat Science, 2003

Effect of stun duration and current level applied during head to back and head only electrical stunning of pigs on pork quality compared with pigs stunned with CO_2

Attribute	CO_2 stunning (n=12)	Electrical stunning treatment				
		1.3 A, 4 s (n=8)	0.9 A, 19 s (n=7)	1.3 A, 19 s (n=7)	2.8 A, 4 s (n=7)	2.0 A, 19 s (n=7)
LTL muscle						
pH 24 h						
Site 1	5.56	5.52	5.48	5.49	5.50	5.50
Site 2	5.56	5.48	5.45	5.45	5.48	5.52
Site 3	5.60	5.53	5.47	5.44	5.48	5.52
Muscle lightness (L*)	50.90	50.65	51.29	53.92	51.96	51.98
Drip loss (%)	4.46	6.71	5.10	9.53	7.06	7.14
WB shear force (kg)	3.47	3.20	3.80	3.24	3.39	3.09
Incidence of PSE[a] (%)	42	38	86	100	71	86
BF muscle						
pH 24 h	5.60	5.59	5.54	5.60	5.59	5.58
Muscle lightness (L*)	49.22	49.61	49.48	51.79	50.73	50.57
Drip loss (%)	3.15	5.48	3.44	5.67	4.15	5.10
WB shear force (kg)	7.72	8.35	7.77	7.72	8.28	8.17
Incidence of PSE[a] (%)	8	0	57	71	14	43
Ecchymosis (g 4mm/pieces)						
Shoulder	0	200	99	157	143	134
Middle	0	16.2	13.8	54.5	38.6	46.9
Incidence of bone fractures (%)[b]	0	25	0	14	43	0

1. *M. longissimus thoracis et lumborum* (LTL) muscle에서 Electrical stunning는 CO_2 stunning보다 많은 drip loss를 유발했지만 0.9A, 19s의 경우 CO_2와 동일한 drip loss를 보였음
2. 1.3A, 4s를 제외한 Electrical stunning는 높은 PSE 출현률을 보였음

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도축 기절 방식이 돈육품질에 미치는 영향

■ Meat Science, 2003

Effect of stun duration and current level applied during head to back and head only electrical stunning of pigs on pork quality compared with pigs stunned with CO_2

Attribute	CO_2 (n = 12)	Head only 1.3 A, 4 s (n = 8)	Head to back electrical stunning			
			0.9 A, 10 s (n = 7)	1.3 A 4 s (n = 7)	1.3 A, 10 s (n = 7)	2.0 A, 4 s (n = 7)
LTL muscle						
pH 24 h						
Site 1	5.68	5.65	5.61	5.61	5.64	5.56
Site 2	5.62	5.59	5.52	5.49	5.60	5.51
Site 3	5.62	5.62	5.52	5.47	5.64	5.48
Muscle lightness (L*)	48.34	50.53	49.51	50.17	47.93	49.34
Drip loss (%)	2.39	4.70	4.70	4.86	4.33	3.70
WB shear force (kg)	3.74	3.94	6.83	6.34	8.43	8.33
Cooking loss (%)	32.6	33.2	33.6	32.9	33.5	33.1
Incidence of PSE[1] (%)	8	38	57	57	57	57
BF muscle						
pH 24 h	5.73	5.63	5.63	5.57	5.68	5.57
Muscle lightness (L*)	46.83	48.63	49.68	49.89	48.04	48.40
Drip loss (%)	1.87	3.23	2.82	3.62	2.95	3.04
WB shear force (kg)	7.13	8.48	7.89	8.64	8.25	7.72
Cooking loss (%)	33.9	33.3	34.1	35.5	32.9	32.6
Incidence of PSE[1] (%)	8	0	14	28	28	0
Endymosis (g tissue/primal)						
Shoulder	11	319	346	384	406	409
Incidence of bone fractures (%)[2]	8	28	28	57	28	28

1. M. longissimus thoracis et lumborum (LTL) muscle에서 Electrical stunning는 CO_2 stunning보다 많은 pH, muscle lightness, tenderness or cooking loss, drip loss and PSE incidence를 유발함

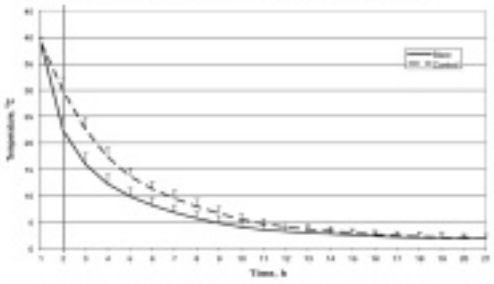
맛 향상 연구

■ Meat Science, 2009

Enhancing pork loin quality attributes through genotype, chilling method and ageing time

Blast-chilling method : −25°C, 2.5m/s wind speed, 1h and cooler room : 2°C, 23h

Conventional chilling method : 2°C, 24h



1. Blast-chilling과 conventional chilling 2시간 째 온도는 7.5°C 차이가 발생함
2. Blast-chilling은 낮은 purge loss와 drip loss를 나타냈으며, 높은 색상(hue angle)을 나타냄
3. Blast-chilling과 conventional chilling 사이의 관능적 특성의 차이는 나타나지 않음

	Genotype		SEM	Chilling		SEM
	Duroc	LW		Blast	Conv.	
pH	5.65	5.64	0.02	5.63	5.63	0.02
Purge loss (mg.g^{-1})	23.92	25.15	1.40	21.91	27.16	1.40
Moisture (mg.g^{-1})	717.18	742.24	8.98	731.91	733.51	8.98
Fat (mg.g^{-1})	31.85	18.85	2.24	25.18	25.47	2.24
Protein (mg.g^{-1})	230.98	237.55	2.19	236.34	234.18	2.19
Soluble protein (mg.g^{-1})	180.14	185.85	3.76	188.31	187.68	3.76
Drip loss (mg.g^{-1})	40.73	38.44	3.76	37.48	41.69	3.76
Shear force	4.58	4.78	0.23	4.80	4.72	0.23
L	50.12	54.85	0.78	55.34	55.63	0.78
Chroma	11.54	11.55	0.45	11.42	11.66	0.45
Hue	35.21	34.02	0.31	34.11	35.13	0.31

	Genotype		SEM	Chilling		SEM
	Duroc	LW		Blast	Conv.	
Sensory characteristics[1]						
Initial tenderness	6.56	6.43	0.13	6.51	6.47	0.13
Juiciness	4.80	4.51	0.08	4.67	4.64	0.09
Flavour desirability	5.23	4.87	0.08	5.07	5.02	0.09
Pork flavour intensity	5.02	4.69	0.05	4.88	4.83	0.05
Off-flavour intensity	7.16	6.74	0.10	6.97	6.94	0.10
Connective tissue	8.25	8.25	0.01	8.25	8.25	0.01
Overall tenderness	6.80	6.62	0.09	6.71	6.71	0.09
Overall palatability	4.72	4.32	0.07	4.54	4.50	0.07

Blast-chilling은 drip loss를 감소시키고 관능적 특성의 차이를 유발하지 않았음

092-107 운성실-수정 2017.02.20 07:29 PM 페이지100 2동양출력02-862-9307

마블링 수준이 맛에 미치는 영향

■ Meat Science, 2010

Effect of visual marbling on sensory properties and quality traits of pork loin

마블링 수준에 따른 관능특성에 미치는 영향과 지방산과의 관계

Table 4
Effect of marbling on sensory properties of pork (visual marbling as a treatment; group = producer as block) (mean ± SEM).

Item[1] n	Marbling 1 26	Marbling 2 11	Marbling 3 15	P
Sensory tenderness	3.88 ± 0.17[a]	4.80 ± 0.22[b]	5.35 ± 0.24[b]	0.001
Sensory juiciness	3.69 ± 0.21[a]	4.32 ± 0.28[a,b]	4.87 ± 0.26[b]	0.017
Sensory off-flavor	7.47 ± 0.09	7.44 ± 0.12	7.43 ± 0.12	0.969

[a,b] Within a row, means without a common superscript letter differ ($P < 0.05$).
[1] Sensory data were obtained using an eight-point hedonic scale.

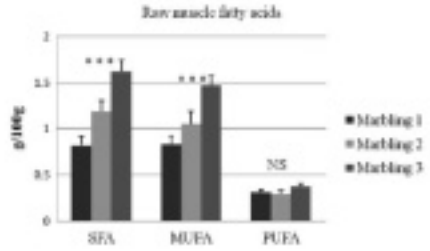


Table 5
Effect of marbling on fatty acid composition (% of total fatty acids) (visual marbling as a treatment; group = producer as block) (mean ± SEM).

Fatty acids n	Marbling 1 26	Marbling 2 11	Marbling 3 15	P
Raw samples				
C14:0 myristic	1.73 ± 0.22	1.71 ± 0.27	1.28 ± 0.28	0.511
C16:0 palmitic	30.30 ± 0.64	31.23 ± 0.80	31.47 ± 0.80	0.559
C18:0 stearic	12.26 ± 0.77	13.90 ± 0.95	13.67 ± 0.96	0.285
C18:1c9 oleic	36.11 ± 1.52	35.28 ± 1.89	38.53 ± 1.89	0.287
C18:1t9 elaidic	4.93 ± 0.47	4.96 ± 0.59	5.37 ± 0.67	0.889
C18:2c9c12 linoleic	12.81 ± 0.56[a]	10.26 ± 0.70[b]	8.90 ± 0.70[b]	0.001
C20:4 arachidonic	3.09 ± 0.15[a]	2.32 ± 0.18[b]	1.72 ± 0.19[b]	0.001
Cooked samples				
C14:0 myristic	1.45 ± 0.15	1.73 ± 0.18	1.84 ± 0.18	0.216
C16:0 palmitic	30.51 ± 1.42	31.10 ± 1.86	36.61 ± 1.78	0.067
C18:0 stearic	9.62 ± 0.98	10.73 ± 1.19	14.55 ± 1.33	0.070
C18:1c9 oleic	37.85 ± 1.66	39.93 ± 2.03	48.48 ± 2.19	0.669
C18:1t9 elaidic	3.58 ± 0.31	3.86 ± 0.38	3.86 ± 0.38	0.810
C18:2c9c12 linoleic	15.10 ± 0.81[a]	10.50 ± 1.01[a,b]	9.16 ± 1.01[b]	0.032
C20:4 arachidonic	3.00 ± 0.20[a]	2.36 ± 0.25[b]	1.82 ± 0.25[b]	0.089

[a,b] Within a row, means without a common superscript letter differ ($P < 0.05$).

1. 마블링 수준이 증가함에 따라 pH, 연도 및 다즙성이 증가함
2. 마블링 수준이 증가할수록 PUFA 비율이 유의적으로 낮아짐
3. linoleic acid와 arachidonic acid는 마블링 수준이 증가함에 따라 감소함

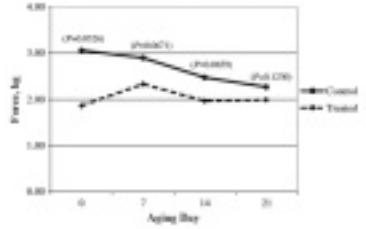
돼지고기 맛 개선을 위한 고압처리 기술

■ Meat Science, 2011

The effects of high pressure processing on pork quality, palatability, and further processed products

Table 1
Effect of HPP on pork quality of individual muscles.

	Longissimus				Psoas major				Triceps brachii				Semimembranosus			
	Con	HPP treated	SEM[1]	P-value	Con	HPP treated	SEM[1]	P-value	Con	HPP treated	SEM[1]	P-value	Con	HPP treated	SEM[1]	P-value
pH	5.78[a]	6.26[b]	0.05	<0.01	6.17	6.31	0.09	0.17	6.08[a]	6.35[b]	0.10	0.04	6.01[a]	6.48[b]	0.07	<0.01
Drip Loss %	2.19[a]	8.39[b]	0.63	0.03	0.54	0.60	0.12	0.64	0.63	0.43	0.17	0.30	2.13[a]	0.33[b]	0.62	<0.01
Color	2.67	2.50	0.31	0.61	5.00[a]	4.00[b]	0.00	<0.01	4.17	3.50	0.35	0.10	5.83	5.17	0.35	0.10
Firmness	2.00[a]	3.33[b]	0.52	<0.01	2.50	2.50	0.45	1.00	2.67	2.83	0.31	0.61	2.50[a]	3.50[b]	0.26	0.01
L*	46.73[a]	58.66[b]	1.48	0.05	36.86[a]	43.22[b]	1.09	<0.01	41.49[a]	44.20[b]	0.69	0.01	46.80[a]	42.49[b]	1.50	0.03
a*	6.07[a]	5.13[b]	0.22	<0.01	14.80	13.76	0.55	0.12	11.67[a]	12.34[b]	0.25	0.04	7.26	7.81	0.73	0.74
b*	3.06[a]	1.59[b]	0.48	0.03	3.98	3.92	0.48	0.90	3.85	3.82	0.18	0.50	2.24	2.81	0.56	0.36
Cook Loss, %	20.58[a]	17.01[b]	0.58	0.01	19.16	17.87	1.51	0.45	18.72	20.52	2.60	0.52	23.71	21.34	2.21	0.33
WBSF, kg[2]	2.46	1.97	0.21	0.07	1.82	2.05	0.36	0.54	2.35	2.35	0.08	0.99	2.49[a]	2.11[b]	0.15	0.03



1. High pressure processing(HPP) : 33°C, 215MPa, 15s
2. HPP는 근육 내 젖산농도를 낮추고 pH를 상승시킴
3. HPP는 대조구보다 낮은 TBARS 값과 전단력을 나타냄
4. HPP는 가열감량과 육즙손실량을 감소시켰으나, 콜라겐 함량에는 차이가 없었음

092-107 운성실-수정 2017.02.20 07:29 PM 페이지101 2동양출력02-862-9307

냉장온도가 우마미 맛 개선에 미치는 영향

■ Meat Science, 2016

Umami and related components in "chilled" pork for the Japanese market

일본시장에 진출하기 위한 캐나다산 수출돈육의 우마미 연관요소 연구



가공 후 4.0±0.3℃에서
5일간 보관

5일 후



수출조건과 동일하게 보관
육 중심온도 −1.70±0.1℃
냉각기 온도 −1.84±0.17℃
상자 내부 온도 −1.75±0.13℃

Table 6
Equivalent umami concentration (EUC) of the 40 pork loins according to ageing and meat type (means with standard deviations in parentheses below; significant differences, $P < 0.05$, shown in bold).

		Ageing time (5 d 4.0 °C or 13–58 d at −1.7 °C)[A]						Meat type		P-value ageing	P-value type
	Overall	0	5	13	28	43	58	Domestic	Export		
EUC (g MSG/100 g dry weight)	2.02 (0.55)	1.37[a] (0.32)	2.42[b] (0.58)	1.94[b] (0.43)	2.11[b] (0.40)	2.18[b] (0.43)	2.18[b] (0.58)	2.04 (0.57)	1.99 (0.55)	< 0.001	0.638
EUC (g MSG/100 g wet weight)	0.540 (0.146)	0.369[a] (0.085)	0.649[b] (0.133)	0.519[b] (0.119)	0.564[b] (0.106)	0.582[b] (0.113)	0.567[b] (0.149)	0.548 (0.136)	0.534 (0.156)	< 0.001	0.080
Number of animals	40	40	40	40	40	40	40	20	20		

[A] Means in a row without a common superscript are significantly different ($p < 0.05$) for ageing time.

−1.7℃으로 43일간 저장된 돈육과 4.0℃에서 5일간 저장된 돈육은 우마미 성분(ECU)에 차이는 없음

4. 육색 및 지방의 특성 개선을 위한 연구 동향

도축단계에서의 육색 측정 기술개발

■ Meat Science, 2008

Prediction of pork color attributes using computer vision system

Computer vision system 회귀분석법을 통한 돈육 등심 색 평가



Computer vision system 이미지 처리 결과

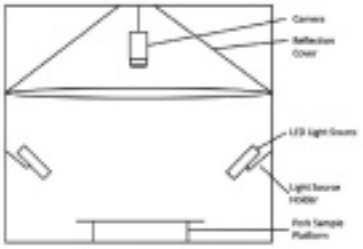


Fig. 1. Pork color image acquisition system.

1. Minolta colorimeter와 Computer vision system의 상관분석
2. 상관분석 추출 항목 : RGB(red, green, blue) model, HSI(hue, saturation, intensity), L*a*b* color spaces
3. Minolta colorimeter와 Computer vision system의 L*, a*, b* 값은 유의적인 연관성을 나타냄
4. linear regression method선형 회귀분석의 $R^2 = 0.83$
5. stepwise regression models단계적 회귀모델의 $R^2 = 0.70$
6. computer vision을 통해 돈육의 육색을 예측하는데 이용될 수 있음

092-107 운성실-수정 2017.02.20 07:29 PM 페이지102 2동양출력02-862-9307

도축단계에서의 육색 측정 기술개발

■ Meat Science, 2011

Lightness of the color measured by computer image analysis as a factor for assessing the quality of pork meat

Table 1
Decision criteria for meat classification (Hospach, 2000).

Meat quality class	pH	Electrical conductivity (mS)	L*
RFN	5.5–5.7	<3.8	45–50
PSE	≥5.5	>3.8	>50

Table 2
Characteristics of pork meat slices of the longissimus muscle classified as PSE or RFN meat.

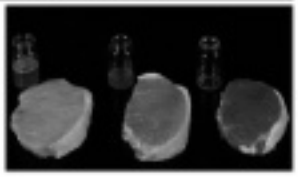
Meat quality class		pH	EC	L*
PSE (n = 14)	X	5.48[a]	10.60[b]	58.01[b]
	SD	0.03	0.98	1.82
RFN (n = 15)	X	5.56[b]	6.46[a]	48.44[a]
	SD	0.05	0.44	0.52

EC – electrical conductivity [mS].
X – average.
SD – standard deviation.
[a,b] – values, in columns, with different letters are significantly different at $p \le 0.05$.

Table 3
Value of RGB [red, green, blue] (-)-HSV/HSB [hue, saturation, value/brightness), HSL [hue, saturation, lightness)-color models and CIELAB color space for PSE and RFN meat.

Meat quality class		Color model Computer image analysis			CIE LAB		
		R	G	B	L*	a*	b*
PSE	X	83.8[a]	69.7[a]	60.9[a]	56.01[a]	9.87[a]	2.88[a]
	SD	2.8	2.6	2.4	1.6	1.7	1.7
RFN	X	81.1[b]	56.5[b]	54.4[b]	48.44[b]	8.84[b]	3.18[b]
	SD	3.4	4.0	5.8	0.5	0.9	0.9
		H	S	V/B			
PSE	X	11.2[a]	32.1[a]	39.6[a]			
	SD	2.5	1.5	1.2			
RFN	X	13.7[b]	33.6[b]	32.2[b]			
	SD	148.8	3.7	1.4			
		H	S	L			
PSE	X	11.2[a]	19.8[a]	39.7[a]			
	SD	2.5	1.6	1.1			
RFN	X	13.7[b]	21.1[a]	28.7[b]			
	SD	148.8	2.4	1.8			

1. pH, 전기 전도율, L*값을 통해 PSE육 표본으로 사용
2. PSE육 표본 사진을 CIA을 통해 분석
3. CIA에 이용된 색 모델은 RGB, HSV/HSB, HSL 3가지를 사용
4. HSV/HSB model의 V/B, HSL model의 L, RGB model의 R, G, B 값이 PSE육을 식별할 수 있음



출하체중이 지방의 특성에 미치는 효과

■ Meat Science, 2008

Effects of growth rate, sex and slaughter weight on fat characteristics of pork bellies

Table 1
Effects of growth rate, sex and slaughter weight on dorsal fat thickness, firmness score and fatty acid profile (percent of total fatty acids) of pork bellies.

	107 kg				115 kg				125 kg				Significance[a]			Interactions			
	A		B		A		B		A		B								
	B	G	B	G	B	G	B	G	B	G	B	G	GR	S	F	GR×S	GR×F	S×F	SEM
Fat thickness (mm)	23.9	19.8	21.7	19.8	23.1	20.2	24.7	20.7	32.1	20.9	28.6	20.4	NS	***	**	NS	NS	**	1.79
Fat firmness[b]	2.4	2.0	1.8	2.0	2.0	2.1	2.4	1.9	2.3	2.1	2.3	1.8	NS	*	NS	NS	NS	NS	0.07
SFA[c]	37.6	35.8	35.9	34.8	36.7	35.4	36.5	35.4	37.3	35.2	35.7	34.5	**	***	NS	NS	NS	NS	0.58
C18:0	12.1	11.4	11.0	10.6	11.4	10.9	11.3	11.1	11.7	10.9	11.1	10.5	**	*	NS	NS	NS	NS	0.34
n-6 C18:2	15.6	14.7	15.4	15.4	14.1	14.9	14.2	15.1	13.9	15.3	14.1	15.6	**	*	NS	NS	NS	NS	0.43
PUFA	15.9	17.2	17.8	17.9	16.5	17.5	16.6	17.5	15.2	17.9	16.5	18.1	**	***	NS	NS	NS	0.06	0.48
Iodine value	66	69	69	71	68	69	68	70	66	70	68	72	**	***	NS	NS	NS	NS	0.38
PUFA:SFA	0.42	0.48	0.50	0.52	0.45	0.49	0.46	0.50	0.41	0.51	0.47	0.53	**	***	NS	NS	NS	NS	0.02
n-6:n-3[d]	16.9	17.5	16.5	16.9	17.1	17.9	17.9	16.6	17.3	16.1	17.0	16.6	**	*	NS	NS	NS	NS	0.33

1. 지방의 경도는 성별에 의해 영향을 받음, gilts showing softer bellies than barrows
2. 성장률이 빠른 거세돈의 경우 삼겹부위의 stearic acid와 SFA 비율이 높음
3. 반대로 성장률이 느린 암퇘지는 SFA 비율이 낮고 linoleic acid, PUFA 비율, Iodine value, PUFA:SFA, n-6:n-3가 높음



092-107 운성실-수정 2017.02.20 07:29 PM 페이지103 2동양출력02-862-9307

삼겹살의 위치별 지방의 특성 연구

■ Meat Science, 2008
Effects of growth rate, sex and slaughter weight on fat characteristics of pork bellies

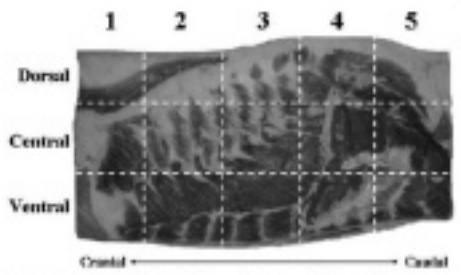


Fig. 1. Division of fresh pork bellies into 3 rows (dorsal, central, and ventral) and 5 columns (labeled 1, 2, 3, 4, and 5 from cranial to caudal).

	Cranial	Columns			Caudal
Rows	1	2	3	4	5
Belly thickness, cm (P<0.001 & SE=0.088)					
Dorsal	3.16[fg]	3.58[cd]	3.22[ef]	2.98[h]	2.72[i]
Central	3.86[d]	3.71[de]	3.86[d]	3.85[d]	3.90[cd]
Ventral	3.29[ef]	3.33[de]	3.16[fg]	3.01[h]	4.02[b]
Lean content,% (P<0.001 & SE=1.72)					
Dorsal	22.6[fg]	19.1[i]	11.3[k]	22.6[fg]	24.0[f]
Central	41.6[d]	38.6[e]	43.2[d]	58.3[a]	55.2[bc]
Ventral	57.7[b]	52.7[bc]	51.9[bc]	51.5[c]	58.0[a]
Fat content,% (P<0.001 & SE=1.30)					
Dorsal	64.4[a]	68.4[a]	75.2[a]	66.6[ab]	58.5[b]
Central	48.6[c]	58.3[b]	43.8[c]	28.5[e]	33.0[de]
Ventral	31.5[de]	36.9[cd]	35.8[cd]	37.3[cd]	38.6[c]
Skin content,% (P<0.001 & SE=0.51)					
Dorsal	12.9[de]	12.0[ef]	13.3[cd]	15.2[b]	16.4[a]
Central	9.5[h]	10.9[fg]	13.7[c]	13.7[c]	10.4[gh]
Ventral	10.7[gh]	10.3[gh]	12.1[ef]	10.9[fg]	10.6[gh]

1. Dorsal(등쪽) : D-3 지방함량 높음
2. Central(중심) : C-4 지방함량 낮음
3. Ventral(복부쪽) : V-1 지방함량 낮음

■ Meat Science, 2011
Compositional and instrumental firmness variations within fresh pork bellies

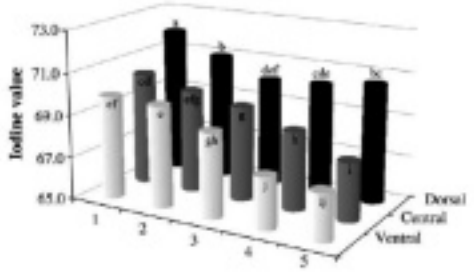
Table 4
Variation in the MUFA composition (weight percentages) within fresh pork bellies.

	Cranial	Columns			Caudal
Rows	1	2	3	4	5
Total MUFA[1],% (P<0.001 & SE=0.333)					
Dorsal	44.08[fg]	43.68[g]	44.30[ef]	45.10[bc]	44.89[cd]
Central	44.92[de]	44.65[ef]	46.03[ab]	46.84[a]	45.07[bc]
Ventral	46.06[ab]	45.72[c]	46.00[ab]	45.34[c]	44.94[d]

Table 5
Variation in the PUFA composition (weight percentages) within fresh pork bellies.

	Cranial	Columns			Caudal
Rows	1	2	3	4	5
Total PUFA[1],% (P<0.001 & SE=0.752)					
Dorsal	20.81[c]	20.25[d]	19.39[ef]	19.10[fg]	19.44[ef]
Central	19.24[hij]	19.03[ij]	18.18[k]	17.55[l]	17.91[kl]
Ventral	18.42[k]	18.54[k]	17.87[l]	17.23[m]	17.34[m]

1. Dorsal(등쪽) : PUFA 함량이 높음, D-3 MUFA 함량 낮음
2. Central(중심) : C-4 PUFA 함량 낮음 MUFA 함량 높음
3. Ventral(복부쪽) : V-1 MUFA 함량 높음, V-4, V-5 PUFA 함량 낮음



1. Iodine value는 D-1에서 가장 높았으며, C-5, V-4, V-5에서 가장 낮았음
2. 삼겹 부위에 따라 지방산 조성이 다르며, 이는 삼겹 지방 경도에 영향을 미침

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숙성이 지방산 변화에 미치는 효과

■ Food Research International, 2013
Changes in polar and non-polar lipid fractions of subcutaneous fat from Iberian ham during dry-curing process. Prediction of the curing time

Table 1
Effect of the dry-curing process on the lipid composition.

Phospholipids	mg kg^{-1} of DC	
	Raw	Dry-cured
CL	0.806 ± 0.048	<0.017
PE	0.367 ± 0.017	<0.016
PI	0.070 ± 0.005	<0.018
PS	0.135 ± 0.016	<0.039
PC	0.331 ± 0.034	<0.040
SPH	0.008 ± 0.014	<0.025
Total PLs	0.913 ± 0.0109	-
SFA	230,551.8 ± 18,251.8	233,175.7 ± 27,419.8
MUFA[a]	528,019.5 ± 18,288.2	560,161.0 ± 33,468.1
PUFA[b]	89,050.6 ± 6246.1	67,871.0 ± 6356.8
Total NF	847,481.3 ± 36,213.9	648,227.7 ± 66,287.3
DBN0[c]	8975.1 ± 2375.6	11,289.3 ± 2081.8
DBN1	90,835.6 ± 21,882.8	72,961.8 ± 44,379.7
DBN2[c]	185,384.1 ± 34,857.5	166,601.1 ± 26,819.8
DBN3[d]	110,249.0 ± 31,298.8	74,293.0 ± 13,382.3
DBN4[e]	31,242.3 ± 2375.3	18,900.0 ± 3916.8
DBN5[f]	881.57 ± 611.7	180.10 ± 303.8
Total TGs[g]	535,804.1 ± 76,972.1	342,065.3 ± 44,434.5
Total L2[h]	6250 ± 99.8	11,489.7 ± 4880.9
Total L3[h]	1828 ± 31.1	13,761.8 ± 6943.1
Total DGs[g]	9955.0 ± 130.1	27,299.3 ± 9395.5
Total MGs[g]	255.1 ± 24.39	6390.1 ± 2255.1
Palmitic acid[a]	427 ± 13.4	13,933 ± 183.88
Oleic acid[a]	1518 ± 48.7	53,853 ± 3690.9
Total (Fatty[a]	3265 ± 83.8	68,848 ± 4283.5

Data are the means ± standard deviation (n = 5). Different letters indicate significant differences between raw and dry-cured data (a for p < 0.05, b for p < 0.01, c for p < 0.001, d for p < 0.0001 and e for p < 0.00001). DBN = double bond number in TGs.

1. 숙성이 진행되면서 Total fatty acid, triacylglycerol, phospholipid은 감소하고 diacylglycerol, monoacylglycerol, free fatty acid는 증가함



지방의 특성 분석을 위한 기술개발

■ Meat Science, 2013
Evaluating the ability to measure pork fat quality for the production of commercial bacon

Table 5
Pairwise correlation coefficients for slice yield from population derived fat quality measures.[1,2,3]

Data	IV>74	Durometer<50	FQS>3
Combined weight classes	−0.21	−0.40*	−0.42*
4.5–5.5 kg	−0.13	−0.38	−0.34
5.5–6.4 kg	−0.36	0.53*	−0.75**

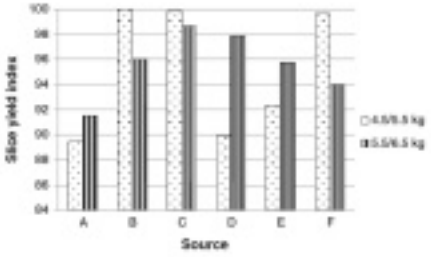


Fig. 1. Belly source and weight class interaction for slice yield index.

1. FTNIR spectrophotomete와 Oscar Mayer사의 Fat Quality Score를 이용한 Fat quality 측정
2. Durometer를 이용한 Fat firmness 측정
3. 삼겹 무게별 지방품질에 대한 척도 측정
4. Durometer 〈 50, FQS 〉 3 일 때 지방품질과 베이컨 수율은 높은 상관관계를 나타냄

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지방의 특성 분석을 위한 기술개발

■ Meat Science, 2013
Evaluating the ability to measure pork fat quality for the production of commercial bacon

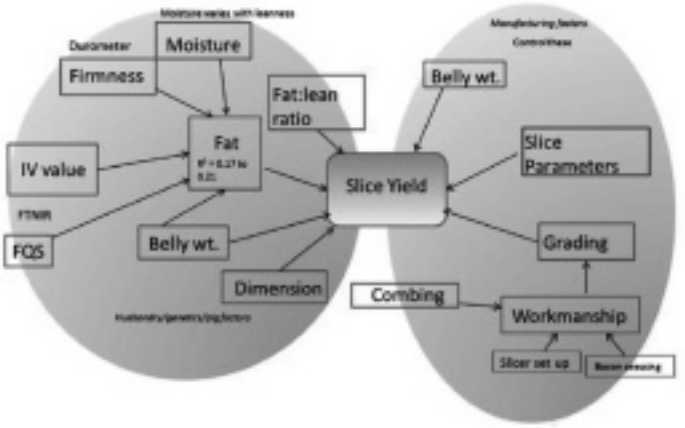


Fig. 3. A model to illustrate why slice yield prediction is imprecise[

사양방법이 지방의 특성변화에 미치는 효과

■ Journal of Animal Science, 2008
Effects of temperature stress on growth performance and bacon quality in grow-finish pigs housed at two densities

Table 3. Humidity, and high and low temperatures for the 35-d study of pigs housed at target temperatures of either 23.9 or 32.2°C[1,2]

Item	23.9°C	32.2°C
High temperature, °C	32.6 ± 0.15	35.4 ± 0.35
Low temperature, °C	20.4 ± 0.12	27.0 ± 0.48
Humidity, %	43.2 ± 0.88	69.0 ± 2.20

1. 온도 조건에 따라 35일간 사양(gilts(n=240), 88±0.4kg)
2. 32.2°C은 Lean:fat 비율이 높음
3. 32.2°C은 raw, cooked weight가 낮음
4. 32.2°C은 collagen content가 높음

Table 5. Effects of temperature and spatial allocation on lean content and cooking characteristics of bacon slices[1]

	23.9°C		32.2°C			P-value		
Item	0.93 m²	0.66 m²	0.93 m²	0.60 m²	SEM	T[3]	S[3]	T × S[3]
Belly weight,[2] kg	4.48	4.57	4.41	4.56	0.06	0.57	0.03	0.58
Lean, %	51.6	53.53	55.72	57.85	1.14	<0.01	0.06	0.93
Fat, %	48.4	46.47	44.28	42.15	1.14	<0.01	0.06	0.93
Lean:fat	1.12	1.22	1.33	1.46	0.06	<0.01	0.03	0.75
Raw slice score[3]	1.75	1.85	2.07	2.29	0.10	<0.01	0.09	0.53
Raw weight, g	32.54	34.53	29.41	28.87	1.11	<0.01	0.50	0.24
Cooked weight, g	10.03	10.94	9.41	9.1	0.47	<0.01	0.50	0.17
Raw length, cm	24.98	24.72	25.70	25.35	1.17	0.78	0.25	0.34
Cooked length, cm	15.59	15.59	14.94	14.98	0.20	<0.01	0.50	0.67
Collagen content, g/100 g	0.99	1.05	1.19	1.17	0.05	<0.01	0.74	0.35



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사양방법이 지방의 특성변화에 미치는 효과

Table 2. Fatty acid profile, iodine value (IV), and saturated:unsaturated (SAT:UNSAT) and n-6: n-3 ratios of diets fed to grow-finish pigs

Fatty acid	Amount in diet
14:0	0.57
14:1	0.02
15:0	0.03
16:0	15.43
16:1	0.72
17:0	0.17
17:1	0.12
18:0	6.19
18:1 trans-9	0.58
18:1n-9	31.58
18:1n-7	ND[1]
18:2	40.43
18:3	1.58
18:4	0.06
20:0	0.38
20:1n-9	0.47
20:3	0.02
20:4n-6	0.08
22:0	0.28
22:1n-9	0.02
22:5	0.02
22:6	ND
24:0	0.24
24:1n-9	ND
IV[2]	102.71
SAT:UNSAT[3]	0.30
n-6:n-3[4]	25.34

Table 6. Effect of temperature and spatial allocation on fatty acid profiles, iodine values (IV), saturated:unsaturated (SAT:UNSAT), and n-6:n-3 of back and belly fat from grow-finish pigs[1]

	19.9°C		32.2°C			P-value		
Fatty acid	0.93 m^2	0.86 m^2	0.93 m^2	0.86 m^2	SEM	T[2]	S[3]	T × S[4]
14:0	1.33	1.34	1.34	1.33	0.02	0.83	0.61	0.37
16:0	22.98	22.55	22.05	21.44	0.27	0.07	0.49	0.05
16:1n-7	2.13	2.14	2.07	2.05	0.06	0.20	0.85	0.79
16:2n-4	0.28	0.30	0.29	0.31	0.02	0.73	0.86	0.9
16:3n-4	0.22	0.25	0.21	0.22	0.02	0.21	0.29	0.14
18:0	11.71	11.79	11.96	11.31	0.23	0.8	0.18	0.09
18:1n-9	38.87	37.98	38.89	38.91	0.48	<0.01	0.14	0.28
18:1n-7	2.74	2.77	2.73	2.83	0.08	0.23	0.69	0.24
18:2n-6	16.86[b]	16.98[b]	18.47[a]	18.46[a]	0.48	<0.01	<0.01	0.03
18:3n-4	0.02	0.05	0.03	0.04	0.02	0.77	0.04	0.03
18:3n-3	0.57	0.61	0.64	0.69	0.02	<0.01	<0.01	0.63
18:4n-3	0.10	0.11	0.10	0.09	0.01	0.26	0.63	0.11
18:3 trans-10, cis-12	0.02	0.02	0.05	0.04	0.02	0.26	0.62	0.99
20:0	0.28	0.31	0.30	0.35	0.02	<0.01	0.16	0.65
20:1n-9	0.64	0.72	0.71	0.65	0.05	0.80	0.95	0.11
20:3n-6	0.01	0.01	0.05	0.03	0.01	0.03	0.11	0.43
21:0	0.09	0.11	0.1	0.10	0.01	0.80	0.41	0.70
20:4n-6	0.28	0.29	0.33	0.36	0.02	0.41	0.10	0.06
20:5n-3	ND[5]	ND	0.01	ND	0.02	0.33	0.33	0.33
22:0	0.2	0.22	0.28	0.24	0.07	0.11	0.83	0.66
22:4n-6	0.1	0.12	0.23	0.1	0.01	0.88	0.70	0.07
22:5n-3	0.06	0.09	0.07	0.06	0.01	0.21	0.44	0.02
24:0	0.03	0.03	0.05	0.03	0.01	0.76	0.13	0.06
22:6n-3	0.03	0.03	0.03	0.03	0.03	0.24	0.85	0.95
IV[6]	66.87[b]	66.56[b]	68.44[a]	70.35[a]	0.83	0.84	0.01	0.01
SAT:UNSAT[7]	0.58	0.59	0.6	0.56	0.01	0.83	0.17	0.03
n-6:n-3[8]	25.77[a]	23.59[b]	22.98[b]	25.27[a]	0.78	0.46	0.86	<0.01

1. 동일한 fatty acid 조성을 가진 사료를 급여하여도 사양하는 온도에 따라 fatty acid 조성이 달라짐
2. 32.2°C의 조건은 삼겹지방 내 oleic acid(18:1n-9) 함량을 감소시키며, linoleic acid(18:2n-6), linolenic acid(18:3n-3) 함량을 증가시킴

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