Innovative rearing strategies for heavy pigs: weight and chemical composition of dry-cured hams

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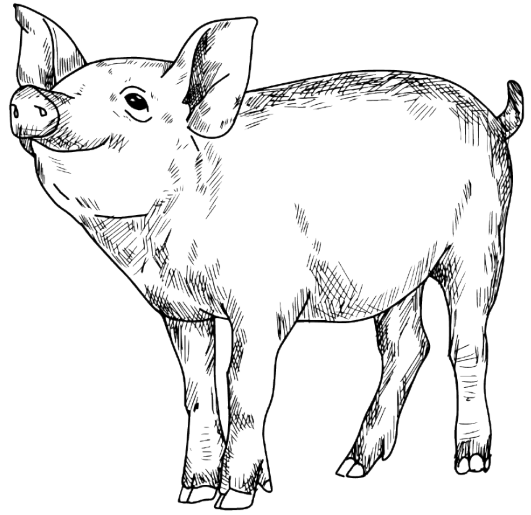
PDO specifications set **limits** for **slaughter weight** (SW) and **slaughter age** (SA)

Proposal of **three different rearing strategies** to be compared with the traditional one

Importance of **maintaining** or **improving** the **quality of dry-cured hams**

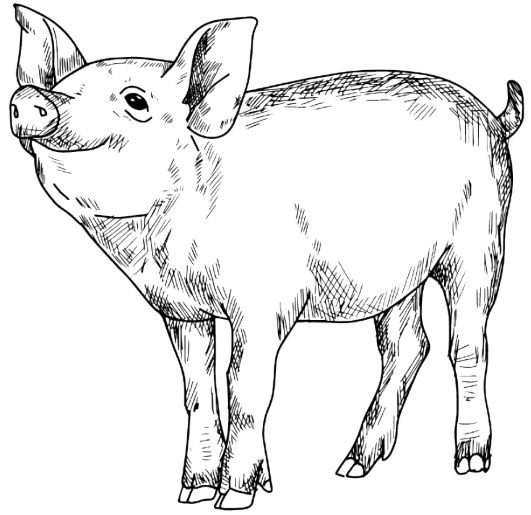
EXPERIMENTAL DESIGN



336 pigs (Goland C21) balanced for sex

4 rearing strategies:

EXPERIMENTAL DESIGN

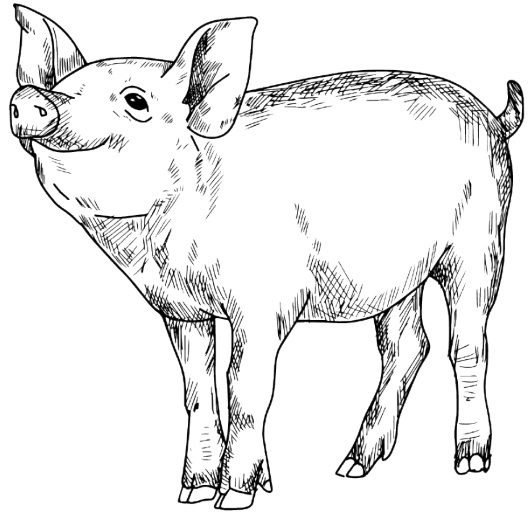


336 pigs (Goland C21) balanced for sex

4 rearing strategies:

C = **control** group, restrictive **medium protein diet**,
SW: 170 kg, SA: 265 d

EXPERIMENTAL DESIGN



336 pigs (Goland C21) balanced for sex

4 rearing strategies:

C = **control** group, restrictive **medium protein diet**,
SW: 170 kg, SA: 265 d

OA = **older age** group, restrictive **low protein diet**,
SW: 170 kg, SA: 278 d

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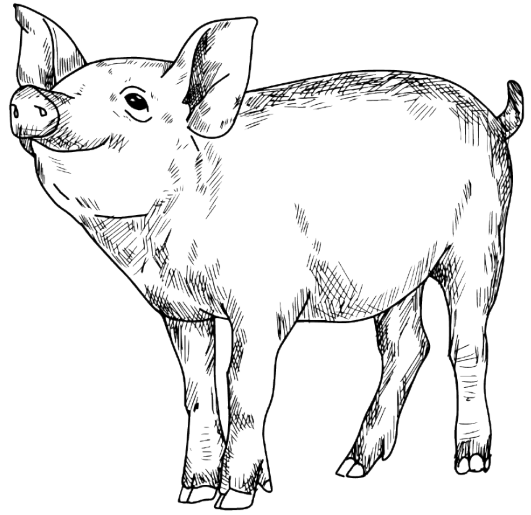


336 pigs (Goland C21) balanced for sex

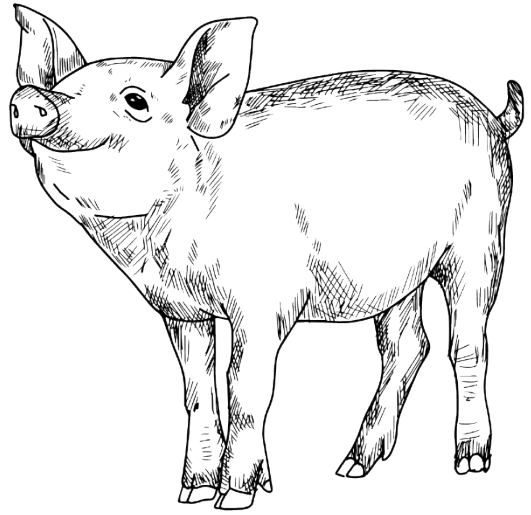
4 rearing strategies:

C = **control** group, restrictive **medium protein diet**,
SW: 170 kg, SA: 265 d

OA = **older age** group, restrictive **low protein diet**,
SW: 170 kg, SA: 278 d

YA = **younger age** group, ad libitum **high protein diet**,
SW: 170 kg, SA: 237 d

EXPERIMENTAL DESIGN



336 pigs (Goland C21) balanced for sex

4 rearing strategies:

C = **control** group, restrictive **medium protein diet**,
SW: 170 kg, SA: 265 d

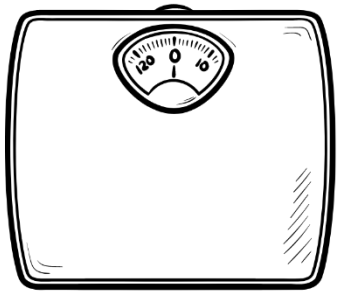
OA = **older age** group, restrictive **low protein diet**,
SW: 170 kg, SA: 278 d

YA = **younger age** group, ad libitum **high protein diet**,
SW: 170 kg, SA: 237 d

GW = **greater weight** group, ad libitum **high protein diet**,
SW: 193 kg, SA: 265 d

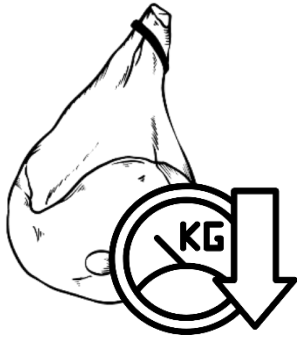
HAM MEASUREMENTS AND EVALUATION

(PERFORMED ON 325 HAMS)



Weighing

Boned and deboned ham



Seasoning loss

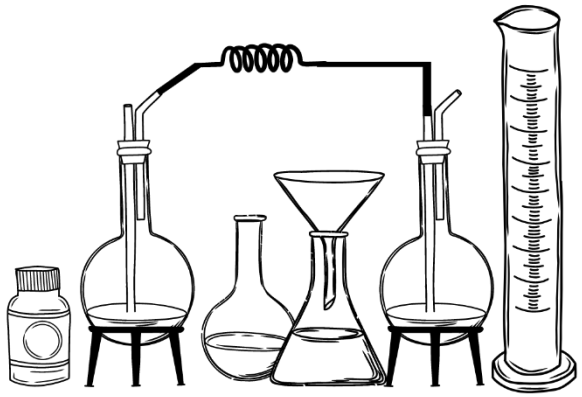
Expressed as % of water loss

Fat cover depth

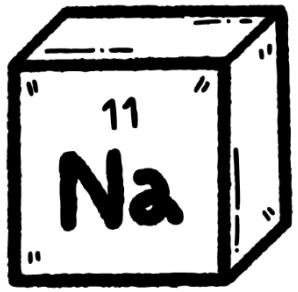
Scored by an expert (1 to 5; 1 = thin, 5 = thick)

CHEMICAL ANALYSIS

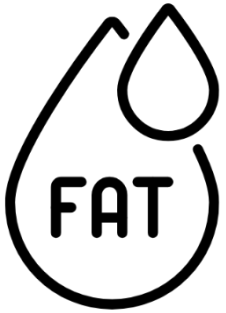
PERFORMED ON 60 HAMS (ACCORDING TO AOAC, 2012)



- Dry matter (#950.46)
- Total protein (#981.10)
  Soluble protein and proteolysis index
- Lipid (#991.36)
  TBARS
- Ash (#920.153)



ICP-OES analysis



GC analysis on lean and fat tissue

STATISTICAL ANALYSIS

First linear mixed model on 325 hams

$$y_{ijklm} = \mu + treat_i + sex_j + (treat \times sex)_{ij} + batch_k + pen(treat \times batch)_{l:ik} + e_{ijklm} \quad (A)$$

- y_{ijklm} was the observed trait;
- μ was the overall intercept of the model;
- $treat_i$ was the fixed effect of the i^{th} treatment (i = 1, …, 4);
- sex_j was the fixed effect of the j^{th} sex (j: 1 = gilts, 2 = barrows);
- $(treat \times sex)_{ij}$ was the interaction effect between treatment and sex;
- $batch_k$ was the random effect of the k^{th} batch (k = 1, …, 3);
- pen_l was the random effect of the l^{th} pen (l = 1,…,8) within the $(treat \times batch)_{ik}$ interaction;
- e_{ijklm} was the random residual.

STATISTICAL ANALYSIS

Second linear mixed model on 60 hams (chemical analysis)

$$y_{ijklm} = \mu + treat_i + sex_j + (treat \times sex)_{ij} + e_{ijklm} \quad \text{(B)}$$

- y_{ijklm} was the observed trait;
- μ was the overall intercept of the model;
- $treat_i$ was the fixed effect of the i^{th} treatment (i = 1, …, 4);
- sex_j was the fixed effect of the j^{th} sex (j: 1 = gilts, 2 = barrows);
- $(treat \times sex)_{ij}$ was the interaction effect between treatment and sex;
- e_{ijklm} was the random residual.

WEIGHT, WEIGHT LOSS AND COVER FAT DEPTH SCORE (N =325)

Item	Rearing strategy					*P*-values		
	C	OA	YA	GW	SEM	C vs OA	C vs YA	C vs GW
Age at slaughter, d	265	278	237	265	-	-	-	-
Whole seasoned ham, kg	9.21	8.97	9.40	10.52	0.11	0.12	0.22	<0.001
Deboned seasoned ham weight, kg	6.90	6.65	7.07	8.00	0.091	0.033	0.17	<0.001
Weight loss, % of green ham weight	29.3	28.8	28.3	27.2	0.35	0.39	0.063	<0.001
Cover fat depth (1 thin, …, 5 thick)	2.59	2.62	3.15	3.49	0.27	0.89	0.014	<0.001

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WEIGHT, WEIGHT LOSS AND COVER FAT DEPTH SCORE (N =325)

Item	Rearing strategy					*P*-values		
	C	OA	YA	GW	Δ (C vs GW)	C vs OA	C vs YA	C vs GW
Age at slaughter, d	265	278	237	265	+14%	-	-	-
Whole seasoned ham, kg	9.21	8.97	9.40	10.52	+16%	0.12	0.22	<0.001
Deboned seasoned ham weight, kg	6.90	6.65	7.07	8.00	- 7.2% +34%	0.033	0.17	<0.001
Weight loss, % of green ham weight	29.3	28.8	28.3	27.2	0.35	0.39	0.063	<0.001
Cover fat depth (1 thin, …, 5 thick)	2.59	2.62	3.15	3.49	0.27	0.89	0.014	<0.001

CHEMICAL COMPOSITION OF THE LEAN TISSUE (N=60)

Item	Rearing strategy					*P*-values		
	C	OA	YA	GW	SEM	C vs OA	C vs YA	C vs GW
Dry matter, %	49.2	50.2	49.8	49.3	0.45	0.11	0.35	0.89
Protein (N×6.25), %	29.7	28.6	30.1	29.2	0.34	0.022	0.44	0.33
Soluble protein, %	8.92	8.22	8.75	8.35	0.17	0.005	0.47	0.022
Proteolysis index, %	30.1	28.8	29.2	28.5	0.50	0.08	0.21	0.030
Lipid, %	10.4	12.6	11.5	11.4	0.59	0.013	0.20	0.24
TBARS, %	2.31	4.18	2.89	2.77	0.50	0.010	0.41	0.52
Ash, %	6.96	6.79	6.69	6.60	0.11	0.29	0.10	0.031
Na, %	2.27	2.23	2.20	2.22	0.07	0.64	0.43	0.54
NaCl (Na×2,50), %	5.68	5.58	5.50	5.54	0.16	0.64	0.43	0.54

CHEMICAL COMPOSITION OF THE LEAN TISSUE (N=60)

Item	Rearing strategy					*P*-values		
	C	OA	Δ (C vs OA)	GW	SEM	C vs OA	C vs YA	C vs GW
Dry matter, %	49.2	50.2	49.8	49.3	0.45	0.11	0.35	0.89
Protein (N×6.25), %	29.7	28.6	30.1	29.2	0.34	0.022	0.44	0.33
Soluble protein, %	8.92	8.22	8.75	8.35	0.17	0.005	0.47	0.022
Proteolysis index, %	30.1	28.8	+21%	28.5	0.50	0.08	0.21	0.030
Lipid, %	10.4	12.6	+81%	11.4	0.59	0.013	0.20	0.24
TBARS, %	2.31	4.18	2.89	2.77	0.50	0.010	0.41	0.52
Ash, %	6.96	6.79	6.69	6.60	0.11	0.29	0.10	0.031
Na, %	2.27	2.23	2.20	2.22	0.07	0.64	0.43	0.54
NaCl (Na×2,50), %	5.68	5.58	5.50	5.54	0.16	0.64	0.43	0.54

CHEMICAL COMPOSITION OF THE LEAN TISSUE (N=60)

Item	Rearing strategy				*P*-values			
	C	OA	YA	GW	Δ (C vs GW)	C vs OA	C vs YA	C vs GW
Dry matter, %	49.2	50.2	49.8	49.3	0.45	0.11	0.35	0.89
Protein (N×6.25), %	29.7	28.6	30.1	29.2	-6.4%	0.022	0.44	0.33
Soluble protein, %	8.92	8.22	8.75	8.35	-5.3%	0.005	0.47	0.022
Proteolysis index, %	30.1	28.8	29.2	28.5	0.50	0.08	0.21	0.030
Lipid, %	10.4	12.6	11.5	11.4	0.59	0.013	0.20	0.24
TBARS, %	2.31	4.18	2.89	2.77	0.50	0.010	0.41	0.52
Ash, %	6.96	6.79	6.69	6.60	0.11	0.29	0.10	0.031
Na, %	2.27	2.23	2.20	2.22	0.07	0.64	0.43	0.54
NaCl (Na×2,50), %	5.68	5.58	5.50	5.54	0.16	0.64	0.43	0.54

FATTY ACID PROFILE (%) OF THE SUBCUTANEOUS FAT (N=60)

Item	Rearing strategy					*P*-values		
	C	OA	YA	GW	SEM	C vs OA	C vs YA	C vs GW
Lipid, %	89.84	90.63	91.01	90.61	0.51	0.27	0.11	0.29
ΣSFA	33.48	32.99	35.31	35.07	0.310	0.27	<0.001	<0.001
16:0	21.95	21.60	23.13	22.97	0.20	0.21	<0.001	<0.001
18:0	8.80	8.67	9.33	9.29	0.16	0.58	0.024	0.039
ΣMUFA	49.81	50.41	49.80	50.44	0.310	0.16	0.99	0.14
c18:1	42.20	42.82	42.12	42.73	0.29	0.14	0.86	0.21
ΣPUFA	16.71	16.60	14.88	14.49	0.220	0.79	<0.001	<0.001
c18:2n-6	13.48	13.40	11.97	11.68	0.26	0.80	<0.001	<0.001
c18:3n-3	1.18	1.13	1.08	1.01	0.03	0.17	0.021	<0.001

FATTY ACID PROFILE (%) OF THE SUBCUTANEOUS FAT (N=60)

Item	Rearing strategy					*P*-values		
	C	Δ (C vs YA)	YA	GW	Δ (C vs GW)	C vs OA	C vs YA	C vs GW
Lipid, %	89.84	+5.5%	91.01	90.61	+4.7%	0.27	0.11	0.29
ΣSFA	33.48	32.99	35.31	35.07	0.310	0.27	<0.001	<0.001
16:0	21.95	21.60	23.13	22.97	0.20	0.21	<0.001	<0.001
18:0	8.80	8.67	9.33	9.29	0.16	0.58	0.024	0.039
ΣMUFA	49.81	-11%	49.80	50.44	-13%	0.16	0.99	0.14
c18:1	42.20		42.12	42.73		0.14	0.86	0.21
ΣPUFA	16.71	16.60	14.88	14.49	0.220	0.79	<0.001	<0.001
c18:2n-6	13.48	13.40	11.97	11.68	0.26	0.80	<0.001	<0.001
c18:3n-3	1.18	1.13	1.08	1.01	0.03	0.17	0.021	<0.001

PRINCIPAL OUTCOMES

All rearing strategies impact the final product

OA treatment: lighter hams, intramuscolar fat and TBARS

YA treatment: fat cover depth, minor changes in chemical composition

GW treatment: heavier hams, fat cover depth, seasonig loss

Thanks!!

Questions?

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DIET COMPOSITION

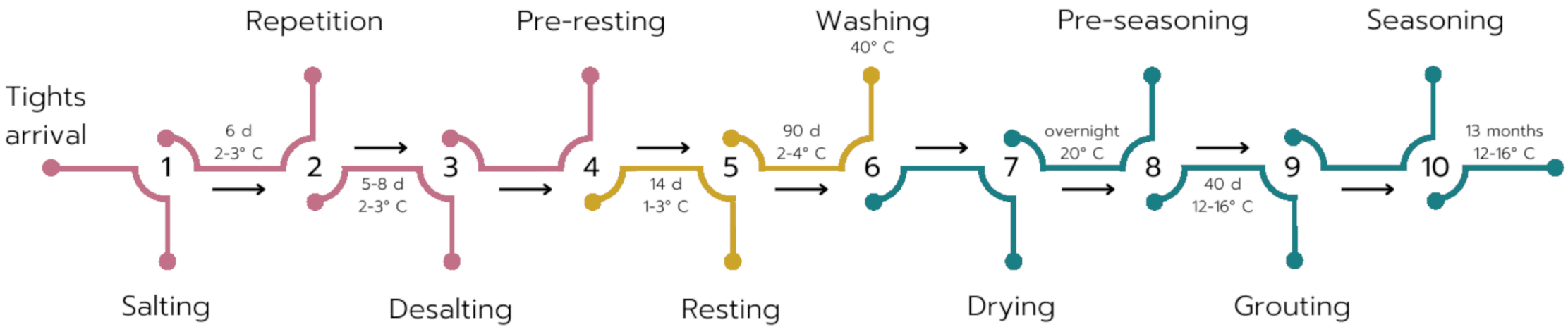
Ingredient	Early Finishing Feeds			Late Finishing Feeds		
	High Protein	Medium Protein	Low Protein	High Protein	Medium Protein	Low Protein
Corn grain	361.3	350.0	390.0	398.3	398.3	398.8
Wheat grain	240.0	270.0	260.0	237.8	237.3	237.5
Barley grain	100.0	100.0	100.0	100.0	100.0	100.0
Soybean meal 48% (solv. ex.)	196.0	85.0	38.0	143.0	56.0	18.3
Wheat bran	26.5	87.5	85.3	7.5	57.5	62.5
Wheat middlings	-	20.0	30.0	40.0	67.5	90.0
Cane molasses	20.0	20.0	20.2	22.5	22.5	22.5
Lard	20.0	21.6	21.0	20.0	20.0	20.0
Dried sugar beet pulp	-	10.0	20.0	-	10.0	20.5
Calcium carbonate	15.0	15.0	15.0	13.0	13.0	13.0
Dicalcium phosphate	4.5	4.5	4.5	2.0	2.0	2.0
Sodium chloride	3.0	3.0	3.0	3.0	3.0	3.0
Sodium bicarbonate	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin and mineral premix [a]	2.0	2.0	2.0	2.0	2.0	2.0
Grapeseed meal	7.5	7.5	7.5	7.5	7.5	7.5
Choline, liquid, 75% [b]	0.5	-	-	-	-	-
L-Lysine [c]	1.0	1.4	0.65	-	1.0	1.0
DL-Methionine [d]	0.2	-	-	-	-	-

[a] Providing per kilogram of feed: vitamin A, 8000 IU; vitamin D3, 1200 IU; vitamin E, 8 mg; Vitamin B7, 0.08 mg; vitamin B12, 0.012 mg; niacin, 16.0 mg; biotin, 8 mg; iron, 170 mg; zinc, 117 mg; copper, 14 mg; cobalt, 0.11 mg; iodine, 0.06 mg; manganese, 65 mg; magnesium, 0.14 mg; selenium 10 mg. [b] Choline liquid 75% (Methodo Chemicals, 42017 Novellara, RE, Italy). [c] L-Lysine Monoclohydrate, 98.5% pure, 78% L-Lysine (Methodo Chemicals, 42017 Novellara, RE, Italy). [d] DL-Methionine, 98% pure min. (Methodo Chemicals, 42017 Novellara, RE, Italy).

DIET COMPOSITION

Item	Early finishing feeds (90 to 120 kg body weight)			Late finishing feeds (over 120 kg body weight)		
	OA[3]	C[4]	YA and GW[5]	OA[3]	C[4]	YA and GW[5]
Analyzed composition						
Dry matter	90.4	90.4	90.6	90.4	90.2	90.6
Net Energy (MJ/kg)	10.1	10.0	10.0	9.9	10.0	10.1
Crude protein (N x 6.25)	11.3	12.8	16.2	10.4	11.9	13.8
Ether Extract	4.4	4.6	4.3	4.8	5.0	4.8
Fatty acid profile						
16:0	8.0	8.0	7.3	7.8	7.7	7.34
18:0	2.9	3.0	2.8	2.8	2.8	2.8
c18:1	13.0	13.0	12.2	12.6	12.6	12.3
c18:2n-6	13.1	12.7	11.4	13.0	12.7	11.7
c18:3n-3	0.8	0.8	0.7	0.8	0.8	0.7

PRODUCTION OF PDO DRY CURED HAM



FATTY ACID PROFILE (%) OF THE INTRAMUSCULAR FAT (N=60)

Item	Rearing strategy					P-values		
	C	OA	YA	GW	SEM	C vs OA	C vs YA	C vs GW
ΣSFA	35.05	34.81	36.42	36.14	0.437	0.70	0.030	0.08
16:0	22.56	22.36	23.44	23.37	0.26	0.61	0.020	0.032
18:0	10.30	10.22	10.77	10.58	0.22	0.80	0.13	0.37
ΣMUFA	49.77	51.64	50.04	50.96	0.337	<0.001	0.56	0.016
c18:1	41.22	41.72	41.61	42.23	0.30	0.001	0.36	0.024
ΣPUFA	15.19	13.55	13.54	12.90	0.420	0.008	0.007	<0.001
c18:2n-6	12.50	11.12	11.11	10.59	0.35	0.007	<0.001	<0.001
c18:3n-3	0.91	0.77	0.83	0.76	0.04	0.010	0.15	0.009

FATTY ACID PROFILE (%) OF THE INTRAMUSCULAR FAT (N=60)

Item	Rearing strategy					P-values		
	C	OA	YA	GW	SEM	C vs OA	C vs YA	C vs GW
ΣSFA	35.05	34.81	36.42	36.14	0.437	0.70	0.030	0.08
16:0	22.56	22.36	23.44	23.37	0.26	0.61	0.020	0.032
18:0	10.30	10.22	10.77	10.58	0.22	0.80	0.13	0.37
ΣMUFA	49.77	51.64	50.04	50.96	0.337	<0.001	0.56	0.016
c18:1	41.22	41.72	41.61	42.23	0.30	0.001	0.36	0.024
ΣPUFA	15.19	13.55	13.54	12.90	0.420	0.008	0.007	<0.001
c18:2n-6	12.50	11.12	11.11	10.59	0.35	0.007	<0.001	<0.001
c18:3n-3	0.91	0.77	0.83	0.76	0.04	0.010	0.15	0.009

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ΣSFA	35.05	34.81	36.42	36.14	0.437	0.70	0.030	0.08
16:0	22.56	22.36	23.44	23.37	0.26	0.61	0.020	0.032
18:0	10.30	10.22	10.77	10.58	0.22	0.80	0.13	0.37
ΣMUFA	49.77	51.64	50.04	50.96	0.337	<0.001	0.56	0.016
c18:1	41.22	41.72	41.61	42.23	0.30	0.001	0.36	0.024
ΣPUFA	15.19	13.55	13.54	12.90	0.420	0.008	0.007	<0.001
c18:2n-6	12.50	11.12	11.11	10.59	0.35	0.007	<0.001	<0.001
c18:3n-3	0.91	0.77	0.83	0.76	0.04	0.010	0.15	0.009

FATTY ACID PROFILE (%) OF THE INTRAMUSCULAR FAT (N=60)

Item	Rearing strategy					P-values		
	C	OA	YA	GW	SEM	C vs OA	C vs YA	C vs GW
ΣSFA	35.05	34.81	36.42	36.14	0.437	0.70	0.030	0.08
16:0	22.56	22.36	23.44	23.37	0.26	0.61	0.020	0.032
18:0	10.30	10.22	10.77	10.58	0.22	0.80	0.13	0.37
ΣMUFA	49.77	51.64	50.04	50.96	0.337	<0.001	0.56	0.016
c18:1	41.22	41.72	41.61	42.23	0.30	0.001	0.36	0.024
ΣPUFA	15.19	13.55	13.54	12.90	0.420	0.008	0.007	<0.001
c18:2n-6	12.50	11.12	11.11	10.59	0.35	0.007	<0.001	<0.001
c18:3n-3	0.91	0.77	0.83	0.76	0.04	0.010	0.15	0.009