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Meat quality and cut yield of pigs slaughtered over 100kg live weight

[*Qualidade de carne e rendimento de cortes de suínos abatidos acima de 100kg de peso vivo*]

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ABSTRACT

Meat quality and cut yield of pigs slaughtered between 100 and 150kg live weight were evaluated. Pigs (417 Agroceres PIC barrows and gilts) were fed a daily allowance of 2.8kg per head from 80kg until 100.71±0.85, 118.58±0.99, 134.07±1.18 or 143.90±1.24kg live weight. Seventy-one pigs were used for the evaluation of primal and subprimal cuts. There was no interaction between sex and slaughter weight for any of the evaluated parameters. Ham, shoulder, and loin weights linearly increased ($P<0.01$; R^2: 84.3-93.2%) with increasing slaughter weight, which, however, had little effect on primal cuts meat yield. Increasing slaughter weight promoted a linear ($P<0.05$) and a quadratic ($P<0.01$) increase of red/green coordinate (a* value) of the loin and ham, respectively. Shear force showed a quadratic response ($P<0.05$), with minimum value estimated at 122kg slaughter weight. It was concluded that, under the applied management, increasing slaughter weight increased the volume of meat, but had little effect on meat yield. The meat of pigs slaughtered at heavier weights showed more intense red color and the same intramuscular fat content as lighter pigs, while tenderness was slightly affected.

Keywords: feed restriction, pork production, heavy hogs, carcass grading

RESUMO

Foi avaliada a qualidade da carne e os cortes de suínos abatidos entre 100 e 145kg de peso vivo. Os suínos (417 machos castrados e fêmeas, linhagem Agroceres PIC) foram mantidos sob fornecimento programado de 2,8kg de ração por animal por dia a partir de 80kg até o abate aos: 100,71±0,85, 118,58±0,99, 134,07±1,18 ou 143,90±1,24kg de peso vivo. Destes, 71 suínos foram usados para avaliação dos cortes primários e secundários. Não foi observada interação entre sexo e peso de abate em nenhuma das variáveis avaliadas. Os pesos do pernil, da paleta e do carré aumentaram linearmente ($P<0,01$; R^2 entre 84,3 e 93,2%) com o peso de abate, com pouco efeito sobre o rendimento da carne. A coordenada vermelho/verde (valor de a) aumentou linearmente ($P<0,05$) no lombo e de forma quadrática ($P<0,01$) no pernil com o aumento do peso de abate. A força de cisalhamento apresentou resposta quadrática ($P<0,05$), com redução até o valor mínimo estimado para os 122kg de peso vivo. Conclui-se que, com o manejo utilizado neste estudo, a elevação do peso de abate resulta em aumento na quantidade de carne produzida, com pouco efeito sobre o rendimento de carne. A carne de suínos abatidos em pesos elevados apresenta cor vermelha mais intensa e mesmo nível de gordura intramuscular que a carne de suínos mais leves, enquanto a maciez é alterada apenas de maneira discreta.*

Palavras chaves: restrição alimentar, produção de carne, suíno pesado, tipificação

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INTRODUCTION

In pig production, slaughter weight is a management factor that strongly affects production costs and final product quality. Until the mid 1990s in Brazil, pigs were slaughtered between 90 and 100kg live weight. Reduced fat deposition and better feed efficiency as a result of several technologies adopted by the industry allowed increasing slaughter weight in approximately 20-30kg in the last two decades in the main pig-producing regions of Brazil. However, in other regions, pigs are still harvested at lighter weights, and the optimal slaughter weight relative to cut yield and meat quality has not been determined yet.

Some attempts have been made to evaluate the effect of higher slaughter weights on profitability, carcass quality, primal cut yield (Pinheiro *et al*., 1983; Irgang and Protas, 1986a; Irgang and Protas, 1986b; Santos Filho *et al*., 2001) and pork quality (Sutton *et al*., 1997; Candek-Potokar *et al*., 1998; Monin *et al*., 1999; Latorre *et al*., 2004; Correa *et al*., 2006); however, few have evaluated pigs slaughtered with more than 125kg live weight. The genetic improvement has changed carcass composition in terms of weight and yield of cuts. Moreover, the genetic selection for high lean production also led to changes in the ratio between muscle fiber types, resulting in muscle biochemical changes and negatively affecting meat quality (Lefaucheur *et al*., 2011), which may interact with slaughter weight. Therefore, the aim of this study was to evaluate the weight and composition of cuts, and the meat quality of pigs of a genotype selected for high lean production slaughtered between 100 and 145kg live weight.

MATERIALS AND METHODS

The experimental protocol was approved by the Committee of Ethics for Animal Experimentation of Embrapa Swine and Poultry, in accordance with the ethical principles of animal experimentation of the Brazilian College of Animal Experimentation. The experiment was carried out in two commercial farms located in the central southern region of Paraná, Brazil. A total of 417 crossbred pigs (207 gilts and 210 barrows) were allotted in an experiment with a completely randomized block (farm) design and a 2x4 factorial arrangement of treatments (two sexes x four slaughter weights: 100, 115, 130 and 145kg). Pigs (initial weight = 80±0.40kg) were housed in sex separate pens in groups of 10 or 11 animals, in a total of five pens of each sex per slaughter weight group. Pens had concrete floors, nipple drinkers, and natural ventilation using side curtains. Daily feed allowance was 2.8kg per animal divided in three meals. The diet contained 3,306 kcal/kg metabolizable energy, 14.79% crude protein, 0.57% calcium, 0.34% total phosphorus, 0.24% available phosphorus, 0.87% total lysine, and 0.74% digestible lysine, and consisted of ground corn (77.5%), soybean meal (19.4%), L-lysine (0.077%), and vitamin and mineral supplement (3%).

At the end of the experiment, pigs were transported to the processing plant, located 80-km from the farms. Pigs were weighed eight hours before transportation after being feed-fasted for eight hours, but with *ad libitum* access to water. The final weight of the pigs in the four target slaughter weight groups was 100.71±0.85kg, 118.58±0.99kg, 134.07±1.18kg, and 143.90±1.24kg. After electrical stunning pigs were bled and processed according to the usual procedures of the processing plant.

Primal and subprimal cuts were evaluated in a total of 71 carcasses: six barrows and six gilts of the 100-kg target slaughter weight, 10 barrows and 10 gilts of the 115- and 130-kg target slaughter weight, and 10 barrows and 9 gilts of the 145-kg target slaughter weight. The carcasses selected for the evaluation of cuts were those which weight was closer to the target slaughter weight of the group. The following primal cuts were obtained from the right half of carcasses 24 h after slaughter: ham, shoulder, loin, belly, and boston butt. The meat, skin+fat, and bones of each cut were separated. Meat yield relative to each cut, as well as total weight and yield of meat, skin+fat, and bone of the pooled primal cuts were calculated. The weight of subprimal cuts tenderloin, topside, boneless loin, and boneless boston butt were obtained. Head weight was calculated as the difference of carcass weight minus the sum of feet, tail, jowl, kidneys, perirenal fat, and primal cut weights.

pH values were measured 45 minutes, 12 hours, and 24 hours after slaughter by insertion of an electrode (Hanna Instruments, FC 232D) coupled to a portable pH meter (Hanna Instruments, HI 99163) in the muscles *Longissimus thoracis*, at the last rib and *Semimembranosus.* Twelve hours after slaughter, meat was scored for color and marbling (NPPC, 1999), and meat lightness (L*) and redness (a*) were measured according to the CIELAB system (Minolta Camera Ltda., Japan; illuminant D65; 0° viewing angle; 8 mm measuring area; measuring area of 8 mm diameter; illumination area of 11mm diameter). Color saturation index was calculated according to Little (1975). Drip loss was determined in *Longissimus thoracis* and *Semimembranosus* samples. Approximately 12g samples were placed inside plastic bags specifically used for drip loss analysis. Drip loss was calculated as the difference between initial weight and weight after 48 hours at 7°C, and expressed as a percentage of initial sample weight.

Samples used for dry matter, lipid content, and shear force analyses were frozen at -20°C after collection. The samples used for ether extract and dry matter analyses were freeze-dried (-40°C to 20°C) in a freeze-drier (Liobrás, Model LP810), ground in a refrigerated mill (Foss Tecator 1095, Knifetec Sample), and stored at -25°C. Dry matter and fat contents were determined according to AOAC (1995). Meat texture was determined after thawing the loin samples (at 5°C) to 24°C and cooking in a water bath until sample temperature reached 75°C. When the samples reached room temperature (~20°C) rectangular pieces were cut (1x1x2 cm) and placed perpendicularly to the muscle fiber direction in a Warner-Bratzler apparatus (TA-XTPlus, Stable Micro Systems), previously calibrated to 10-kg standard weight, using an aluminum probe (HDP) and pre-test, post-test, and test speeds of 2.0 mm/s (AMSA, 1995).

The analysis of variance (ANOVA) was performed using the means per pen, by the GLM procedure of SAS (SAS Institute INC, 2011), considering the qualitative effects of slaughter weight, sex, farm, and interaction between sex vs. slaughter weight. This analysis was also used to find the pure error to be tested in the polynomial regression analyses of the first and second order. The measured slaughter weight means and sex vs. slaughter weight interaction were used as independent variables in the analysis of regression. The residuals were investigated regarding ANOVA assumptions using residual plot analysis, tests for normality (Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises and Anderson-Darling) and for homoscedasticity (Levene's test). When the homoscedasticity assumption was not supported, ANOVA weighted by inverse of variance was performed.

RESULTS AND DISCUSSION

There was no interaction ($P>0.05$) between sex and slaughter weight for any of the cut variables. There was no effect of sex on the weight of individual cuts or pooled cuts (Tab. 1 and 2). The lack of effect of sex on cut weight was also observed by other authors for ham (Latorre *et al*., 2004; Correa *et al*., 2006; Latorre *et al*., 2008; Peinado *et al*., 2008), shoulder, loin, and boston butt (Cisneros *et al*., 1996a; Peinado *et al*., 2008), and side plus spareribs (Martin *et al*., 1980; Cisneros *et al*., 1996a) from pigs slaughtered between 107 and 140kg live weight. However, some studies reported higher loin values for gilts (Latorre *et al*., 2004; Correa *et al*., 2006; Latorre *et al*., 2008). Gilts had higher ham and shoulder meat yields ($P<0.006$ and $P<0.004$, respectively), as previously found by Correa *et al*. (2006).

Ham, shoulder, loin, and boston butt weights linearly increased ($P<0.001$), with 0.128, 0.073, 0.079, and 0.020kg per kg of increase in slaughter weight, respectively, (Tab. 3). These increments in the weight of primal cuts are consistent with the value ranges reported in literature of 0.086-0.195kg in ham, 0.036-0.182kg in shoulder, 0.03-0.117kg in loin, and 0.036-0.046kg in boston butt per kg of increase in slaughter weight (Martin *et al*., 1980; Irgang and Protas, 1986b; Cisneros *et al*., 1996a; Dutra Jr *et al*., 2001; Latorre *et al*., 2004; Latorre *et al*., 2008). There was a quadratic effect ($P<0.001$) of slaughter weight on belly weight ($P<0.001$), with maximum point obtained in pigs slaughtered at approximately 145kg, whereas Martin *et al*. (1980) and Cisneros *et al*. (1996a) reported a linear effect.

Tenderloin, boneless boston butt, topside, and boneless loin weights linearly increased with slaughter weight ($P<0.001$), and had a weak to moderate correlation with slaughter weight (R^2 between 47.6 and 87.9%). Cisneros *et al*. (1996a) reported linear increases in boneless loin, tenderloin, and boston butt weights of 38, 5, and 20g per kg of increase in slaughter weight, respectively. Data regarding the effect of slaughter weight on the weight of subprimal cuts are infrequent, warranting the performance of further studies on this subject.

Table 1. Effects of slaughter weight and sex on carcass and primal cuts (means ± standard error) of pigs slaughtered between 100 and 145kg live weight

Parameter	Target slaughter weight (kg)							
	100		115		130		145	
	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt
Live weight, kg	102.75±1.37	100.72±0.92	117.92±0.98	117.04±1.38	133.39±1.16	133.04±1.07	147.01±1.01	143.56±0.95
CCW[1], g	79.74±1.32	78.77±0.75	93.52±0.86	93.08±1.19	107.02±1.09	106.07±0.88	118.48±1.11	115.93±1.06
Other cuts[2,3], kg	2.40±0.16	2.43±0.18	3.12±0.11	3.03±0.10	3.97±0.16	3.76±0.13	4.59±0.13	4.22±0.15
Head[4], kg	3.70±0.51	3.89±0.28	3.68±0.23	4.31±0.31	4.72±0.39	5.56±0.56	4.47±0.33	4.41±0.40
Ham								
Weight, kg	11.77±0.41	12.17±0.41	13.72±0.22	13.93±0.17	15.47±0.20	16.13±0.21	17.64±0.44	17.52±0.35
Meat yield, %	73.28±2.65	76.92±1.36	76.30±1.41	76.47±1.86	78.04±0.79	78.02±0.89	77.48±0.41	77.56±1.20
Shoulder								
Weight, kg	7.31±0.25	6.60±0.16	8.10±0.09	7.85±0.25	8.81±0.27	8.64±0.31	10.24±0.17	10.22±0.32
Meat yield, %	67.03±1.23	66.38±1.58	65.74±2.57	67.14±2.63	70.51±0.75	69.51±0.87	68.03±1.51	69.29±1.31
Loin								
Weight, kg	9.91±0.11	6.56±0.23	8.27±0.26	8.08±0.26	9.44±0.23	8.87±0.28	10.31±0.37	9.91±0.11
Meat yield, %	61.17±1.64	65.55±0.99	59.24±4.26	63.54±3.51	63.18±1.50	66.55±1.68	60.81±2.15	64.29±1.56
Boston butt								
Weight, kg	2.57±0.17	2.48±0.13	2.44±0.12	2.50±0.11	3.08±0.23	3.27±0.24	3.15±0.13	3.40±0.15
Meat yield, %	77.40±0.98	80.31±0.28	77.52±0.48	79.31±0.86	80.11±0.69	82.08±0.75	77.28±0.75	77.65±1.13
Belly								
Weight, kg	7.27±0.2	7.26±0.04	8.99±0.15	8.78±0.10	10.36±0.22	10.04±0.23	10.92±0.26	10.31±0.22
Meat yield, %	45.82±2.48	44.08±0.65	36.20±5.59	39.90±7.85	43.82±10.0	45.75±10.4	41.19±9.40	42.04±8.99

[1] With head, feet, tail, kidneys, and perirenal fat; [2] Feet, tail, jowl, kidneys, and perirenal fat; [3] Relative to half carcass; [4] Calculated per difference; CCW= cold carcass weight.

Table 2. Effects of slaughter weight and sex on pooled primal and subprimal cuts (means ± standard error) of pigs slaughtered between 100 and 145kg live weight

Parameter	Target slaughter weight, kg							
	100		115		130		145	
	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts
Pooled primal cuts								
Total weight[1], kg	35.57±0.59	35.06±0.45	41.54±0.45	41.15±0.53	47.16±0.45	46.95±0.41	52.26±0.43	51.40±0.52
Meat, kg	22.90±0.42	23.23±0.51	25.84±0.57	26.52±0.64	31.24±0.49	31.79±0.67	33.92±0.77	33.37±1.10
Bones, kg	4.85±0.20	4.78±0.15	5.47±0.09	5.41±0.13	6.09±0.06	6.10±0.08	6.61±0.09	6.54±0.18
Skin+fat, kg	7.74±0.38	7.02±0.43	10.03±0.43	9.15±0.39	9.69±0.80	8.93±0.77	11.47±0.71	10.49±0.70
Yield, % live weight	34.62±0.22	34.81±0.27	35.23±0.26	35.16±0.25	35.35±0.22	35.29±0.21	35.55±0.13	35.80±0.21
Yield, % carcass	44.68±0.34	44.44±0.16	45.01±0.41	44.34±0.17	44.09±0.16	43.93±0.24	44.23±0.13	44.44±0.15
Meat yield, %	64.39±0.53	66.25±0.93	62.18±1.09	64.43±1.24	66.36±1.51	67.78±1.57	64.89±1.34	65.00±2.29
Bone yield, %	13.65±0.57	13.64±0.38	13.18±0.19	13.15±0.28	12.91±0.16	12.99±0.14	12.64±0.16	12.70±0.25
Skin+fat yield, %	21.74±0.96	20.04±1.26	24.16±1.09	22.29±1.01	20.44±1.56	18.98±1.57	21.95±1.35	20.37±1.26
Subprimal cuts								
Tenderloin, kg	0.29±0.02	0.28±0.01	0.27±0.01	0.32±0.01	0.34±0.02	0.69±0.01	0.38±0.03	0.38±0.02
Boneless boston butt, kg	1.24±0.06	1.18±0.05	1.24±0.06	1.24±0.06	1.51±0.08	1.59±0.10	1.54±0.09	1.68±0.09
Topside, kg	1.07±0.04	1.29±0.05	1.65±0.22	1.73±0.13	1.78±0.22	1.94±0.19	2.28±0.32	2.19±0.29
Boneless loin, kg	2.35±0.13	2.57±0.14	2.72±0.24	2.87±0.10	3.10±0.10	3.27±0.064	3.41±0.17	3.53±0.18

[1] Relative to half carcass.

Table 3. Parameters of the polynomial analysis of regression of carcass and primal and subprimal cuts data of pigs slaughtered between 100 and 145kg live weight

Dependent variable	Parameter estimates				Pr>F		R^2	Residual error
	Intercept		Linear	Quadratic	Linear	Quadratic		
	Barrows	Gilts						
CCW[1], kg	-8.676	-8.676	0.867	-	<0.001	NS	98.84	1.49
Other cuts[2, 3], kg	-2.322	-2.322	0.046	-	<0.001	NS	78.11	0.39
Head[4], kg	1.481	1.481	0.023	-	0.01	NS	8.95	1.18
Ham								
Weight, kg	-1.178	-1.178	0.128	-	<0.001	NS	93.23	0.56
Meat yield, %	44.043	44.0423	0.467	-0.0016	0.002	0.03	50.10	2.10
Shoulder								
Weight, kg	-0.612	-0.612	0.073	-	<0.001	NS	84.30	0.52
Meat yield, %	58.840	58.840	0.073	-	0.002	NS	49.09	2.75
Loin								
Weight, kg	-1.295	-1.295	0.079	-	<0.001	NS	89.36	0.44
Boston butt								
Weight, kg	0.336	0.336	0.020	-	<0.001	NS	40.73	0.40
Meat yield, %	39.495	41.056	0.637	-0.0026	NS	0.01	28.85	2.06
Belly								
Weight, kg	-15.811	-15.811	0.331	-0.0010	<0.001	0.02	90.66	0.41
Meat yield, %[5]	0.660	0.660	0.767	-0.0034	<0.001	<0.001	86.83	6.35
Pooled primal cuts								
Total weight[3], kg	-2.752	-2.752	0.375	-	<0.001	NS	98.08	0.84
Meat, kg	-2.203	-2.203	0.248	-	<0.001	NS	76.01	2.21
Bones, kg	0.668	0.668	0.041	-	<0.001	NS	81.50	0.31
Skin+fat, kg	-0.086	-0.086	0.076	-	<0.001	NS	29.14	1.88
Yield, live weight %	32.960	32.960	0.018	-	<0.001	NS	16.06	0.66
Bone, %[5]	15.533	15.533	-0.020	-	<0.05	NS	15.35	0.73
Subprimal cuts								
Tenderloin, kg	0.019	0.019	0.002	-	<0.001	NS	55.85	0.04
Boneless boston butt, kg	0.136	0.136	0.010	-	<0.001	NS	47.60	0.18
Topside, kg	-0.665	-0.665	0.019	-	<0.001	NS	87.95	0.20
Boneless loin, kg	0.133	0.133	0.023	-	<0.001	NS	67.60	0.28

[1]With head, feet, tail, kidneys, and perirenal fat; [2]Feet, tail, jowl, kidneys, and perirenal fat; [3]Relative to half carcass; [4]Calculated per difference; [5]ANOVA weighted by inverse of variance was performed; CCW= cold carcass weight; NS = not significant

As expected, the weight of the pooled primal cuts, subprimal cuts, and other cuts (feet, tail, jowl, kidneys, and perirenal fat), as well as the weight of meat, bones, and skin+fat of the pooled cuts linearly increased with slaughter weight (P<0.01 to P<0.001). This is in agreement with the findings of Correa *et al*. (2006), who reported that the weight of pooled subprimal cuts increased with slaughter weight. The increase in meat weight of pooled cuts of the whole carcass obtained in the present study (0.248kg) is consistent with the observations of Cisneros *et al*. (1996a), who reported an increase of 0.140kg in meat weight per kg increase in slaughter weight.

There was an increase of 0.018% in the pooled cuts yield (P<0.001) per kg of live weight increase (Table 3). However, when considered relative to carcass weight, there was no effect of slaughter weight, in agreement with the results of Irgang and Protas (1986b). Meat and skin+fat yields were not affected by slaughter weight, as previously found by Correa *et al*. (2006). However, differently from the results of the present study, Irgang and Protas (1986b) and Cisneros *et al*. (1996a) reported a reduction in the meat yield of pooled cuts. This is probably due to differences in slaughter weight ranges, cut patterns, genetics, nutrition, and feeding management used in these studies. Bone yield of the pooled cuts decreased (P<0.001) as slaughter weight increased, which is consistent with the results obtained by Irgang and Protas (1986b).

The increase in primal cuts yield, associated with the low correlation of primal cuts and meat yield with slaughter weight indicates the advantages of slaughtering heavier pigs, meaning that more meat can be produced per animal at lower processing costs. Market surveys indicate that heavier slaughter weights provide adequate size of special cuts valued by consumers, such as rump cap, tenderloin, boston butt, and topside, but these surveys also showed that traditional cuts, such as loin, boneless loin, ribs, and ham from pigs slaughtered over 105kg are usually rejected by consumers due to their large size. Specific studies evaluating operational issues in processing plants and consumers' preferences are needed.

Increasing slaughter weight led to an increase in a* value and color saturation (P<0.05), suggesting that meat color was redder and more intense in heavier pigs (Table 4). The results of previous studies on pork color changes due to slaughter weight are widely varied. The response observed in the present study is consistent with the findings of Latorre *et al*. (2004) relative to a* value. Reduced loin L* values with increasing slaughter weights were reported by Latorre *et al*. (2004) and Fábrega *et al*. (2011). The more intense red color obtained in heavier pigs in the present study may be related to higher myoglobin content in the muscle, as reported by Latorre *et al*. (2004). Color visual score was influenced by slaughter weight (P<0.05), which differs from Sutton *et al*. (1997) and Correa *et al*. (2006), who did not find an effect of slaughter weight on this variable. Considering the different meat color assessments carried out in this study, the meat of heavy pigs was lighter according to the visual evaluation, but not by instrument evaluation (L* value), showing also more intense red color and higher saturation index. The difference between the visual and instrumental assessment is due to the subjectivity of the visual method, which may be affected by intramuscular fat content, meat exudation, and environmental luminosity.

pH 45 min post-slaughter was quadratically reduced (P<0.05), but the mean values for all slaughter weights are within the range of normal quality meat (initial pH>6.0), according to the standards of the National Pork Producers Council (NPPC, 1999). Twelve hours post-slaughter pH linearly increased with increasing slaughter weight (P<0.05). Twenty four hours post-slaughter, loin pH quadratically increased (P<0.01), but ham pH was not influenced (P>0.05) by slaughter weight. Loin 24-h pH average values for each slaughter weight group were below or at the minimum limit indicated for normal, non-exudative meat (5.6-5.9; NPPC, 1999).

There was no influence of sex on most of the pork quality characteristics, except for marbling, which was higher (P<0.05) in barrows than in gilts (1.41±0.063 *vs.* 1.28±0.043 %, respectively). This result was expected and it is consistent with previous reports (Latorre *et al*., 2003; Suzuki *et al*., 2003; Dugan *et al*., 2004). Interaction of sex *vs.* slaughter weight was observed (P<0.05) on the saturation index, color score, pH 12h of ham and pH 24h of loin. Loin drip loss was not influenced (P>0.05) by slaughter weight, and the average values obtained are within the range expected for normal quality meat (2-6%; NPPC, 1999). Ham drip loss linearly increased (P<0.01) with slaughter weight. These results are consistent with the findings of Candek-Potokar *et al*. (1998), and Correa *et al*. (2006).

Meat pH, particularly initial pH, influence meat quality characteristics, such as color and drip loss. Initial pH was lower in heavier pigs, but with average values above the minimum values for normal meat, and loin 12-h pH and ham 24-h pH were higher in heavier pigs. Therefore, in this study, the higher drip loss observed in heavier pigs cannot be explained by the pH values. Moreover, it should be noted that the pH differences observed for the different slaughter weights may not be related to live weight, but to environmental factors, as the pigs were slaughtered on different dates. Although all groups of slaughter were submitted to the same pre-slaughter management, temperature and other environmental factors may have interfered with the results. These are probably major causes of the wide variability in meat quality reported in different studies, along with genetics, nutritional levels, weight ranges, and management. Therefore, pH and drip loss should be evaluated in the carcass of pigs with different live weights slaughtered at the same time.

Table 4. Mean, standard error, significance level, and parameters of polynomial analysis of regression of meat quality of pigs slaughtered between 100 and 145kg live weight

Dependent variable	Target slaughter weight, kg				Pr>F		Parameter estimates			R^2	Residual
	100	115	130	145	Lin	Quad	Intercept	Lin	Quad		error
				Loin							
L*[1]	44.99 ± 0.30	44.89 ± 0.40	45.17 ± 0.35	45.11 ± 0.46	NS	NS	-	-	-	-	-
a*[1]	7.20 ± 0.08	7.39 ± 0.15	8.05 ± 0.07	7.77 ± 0.13	0.001	NS	5.6112	0.0160	-	0.33	0.40
Saturation index[1]	7.46 ± 0.08	7.61 ± 0.15	8.24 ± 0.07	7.93 ± 0.14	0.001	NS	6.0761	0.0140	-	0.25	0.42
Color score[1,3]	3.50 ± 0.13	3.58 ± 0.12	3.33 ± 0.21	2.90 ± 0.06	0.01	0.04	-0.4395	0.0729	-0.0003	0.53	0.36
Marbling score[1, 3]	1.34 ± 0.07	1.38 ± 0.11	1.40 ± 0.07	1.26 ± 0.05	NS	NS	-	-	-	-	-
pH 45 min	6.34 ± 0.03	6.24 ± 0.04	6.19 ± 0.05	6.15 ± 0.04	0.001	0.02	9.6328	-0.0526	0.0002	0.55	0.10
pH 12 h [5]	5.47 ± 0.05	5.52 ± 0.02	5.50 ± 0.02	5.66 ± 0.03	<0.001	NS	4.4258	0.0084	-	0.80	4.92
pH 24 h[2,5]: Barrows	5.43 ± 0.056	5.60 ± 0.03	5.60 ± 0.04	5.602±0.057	<0.001	<0.001	-0.1521	0.0885	-0.0003	0.59	2.88
Gilts	5.50 ± 0.062	5.60 ± 0.003	5.58 ± 0.04	5.541±0.030	<0.001	0.023	2.6054	0.0497	-0.0002	0.88	1.68
Drip loss[2]	5.25 ± 0.44	4.90 ± 0.68	5.99 ± 0.491	5.28 ± 0.66	NS	NS	-	-	-	-	-
Dry matter[2]	25.51 ± 0.18	25.68 ± 0.30	25.01 ± 0.18	25.06 ± 0.11	0.02	NS	27.1067	-0.0144	-	0.15	0.64
Ether extract[2]	1.72 ± 0.17	1.67 ± 0.18	1.47 ± 0.14	1.42 ± 0.13	NS	NS	-	-	-	-	-
Shear force[2]	3.54 ± 0.23	2.98 ± 0.17	3.45 ± 0.19	4.07 ± 0.29	0.04	0.03	13.2449	-0.1705	0.0007	0.35	0.67
				Ham							
L*[1]	42.58 ± 0.31	41.68 ± 0.18	43.21 ± 0.40	40.91 ± 0.36	NS	NS	-	-	-	-	-
a*[1]	6.54 ± 0.18	6.91 ± 0.18	7.66 ± 0.08	7.46 ± 0.08	0.001	0.01	-6.3219	0.1968	-0.0007	0.59	0.41
Saturation index[1, 4 5:] Bar	6.78 ± 0.35	7.52 ± 0.21	7.82 ± 0.09	7.71 ± 0.13	<0.001	<0.001	-7.9608	0.2314	-0.0008	0.81	1.35
Barrows Barrows											
Gilts	6.52 ± 0.11	6.88 ± 0.32	7.90 ± 0.12	7.65 ±0.04	<0.001	<0.001	-9.6624	0.2578	-0.0010	0.84	1.86
Color score[1,3,4,5]: Bar	3.42 ± 0.12	3.70 ± 0.08	3.61 ± 0.33	2.91 ± 0.09	<0.001	0.001	-7.9860	0.1976	-0.0008	0.60	2.17
Gilts	3.59 ± 0.08	3.81 ± 0.08	3.30 ± 0.21	3.19 ± 0.06	0.002	NS	4.5909	-0.0103	-	0.46	2.41
pH 45 min	6.48 ± 0.03	6.31 ± 0.03	6.34 ± 0.03	6.23 ± 0.02	0.001	0.01	9.5760	-0.0490	0.0002	0.52	0.09
pH 12 h[4,5]: Bar	5.57 ± 0.09	5.61 ± 0.04	5.54 ± 0.02	5.75 ± 0.05	NS	NS	-	-	-	-	-
Gilts	5.59±0.10	5.65 ± 0.02	5.59 ± 0.02	5.78 ± 0.03	<0.001	NS	5.3988	0.0019	-	0.38	11.76
pH 24h[2]	5.58 ± 0.04	5.66 ± 0.02	5.64 ± 0.04	5.65 ± 0.04	NS	NS	-	-	-	-	-
Drip loss[2]	3.25 ± 0.54	4.28 ± 0.33	3.97 ± 0.20	5.03 ± 0.72	0.01	NS	-0.3669	0.0358	-	0.31	1.42

[1]Evaluated 12 hours post-slaughter in all animals; [2]Evaluated 24 hours post-slaughter in 20 animals per slaughter weight; [3]Visual score (color: 1, pale pink, 6, dark red; marbling: 1.1% intramuscular fat, 10, 10% intramuscular fat; NPPC, 1999); [4]Interaction sex X slaughter weight; [5] ANOVA weighted by inverse of variance was performed; Bar = Barrows; Lin = linear effect; Quad = quadratic effect.

Marbling score and ether extract were not influenced (P>0.05) by slaughter weight. These results are consistent with the findings of Monin *et al*. (1999), Latorre *et al*. (2004), Correa *et al*. (2006), and Fábrega *et al*. (2011), but Cisneros *et al*. (1996a) found an increase in intramuscular fat as slaughter weight increased, as well as Candek-Potokar *et al*. (1998) in pigs fed *ad libitum*. An increase in marbling score in the heavier pigs was not expected in this study because pigs were restricted-fed and the diet contained the same amino acid levels along the whole experimental period. Therefore, as slaughter weight increased, amino acid supply exceeded the pigs' requirements. Some factors that increase intramuscular fat content are reduced amino acid levels (Wood *et al*., 2004; Teye *et al*., 2006; Bertol *et al*., 2010), poor dietary amino acid balance (Cisneros *et al*., 1996b), *ad-libitum* feeding, and heavy body weight.

Shear force showed a quadratic response (P<0.05), with the minimum value estimated at 122kg slaughter weight. Candek-Potokar *et al*. (1998), Monin *et al*. (1999), and Latorre *et al*. (2004) did not find any increase in shear force in pigs slaughtered at maximum weights of 127, 130 or 133kg. However, although Cisneros *et al*. (1996a) did not observe any differences in shear force in pigs slaughtered from 100 to 160kg, a reduction in tenderness was detected by a trained panel. The reduced tenderness in heavier pigs may be due to the lower content of soluble collagen in the muscle as the animal ages (Correa *et al*., 2006).

CONCLUSIONS

The significant increase in the weight of primal cuts had little effect on meat yield, showing the advantages of slaughtering heavier pigs. The meat of pigs slaughtered at heavier weights and submitted to feed restriction showed more intense red color and the same intramuscular fat content as lighter pigs. Tenderness slightly changed with slaughter weight when pigs were slaughtered with more than 134kg live weight. The effect of slaughter weight on meat pH and drip loss should be revaluated in future studies by slaughtering pigs of different live weight simultaneously.

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