51st International Congress of Meat Science and Technology
August 7-12, 2005 – Baltimore, Maryland USA

EFFECT OF PRO-LONGED FATTENING ON CARCASS AND MEAT QUALITY IN PIGS

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Key Words: pig, pork, live weight, gender, carcass composition, meat quality

Introduction

Fattening pigs are usually raised up only to a live weight of at most 120 kg. This is a reasonable compromise regarding the requirements of pig producers and the meat industry. With increasing live weight the relative costs for piglets, slaughter and meat inspection may diminish, but simultaneously the carcass is getting fatter and feed costs per kg carcass weight rise due to a deteriorating feed efficiency. Moreover the common exploitation of a pig carcass relies on certain sizes of the different joints obtained from it, which would be exceeded by slaughtering larger pigs. On the other hand the meat of heavier pigs (live weight up to about 160 kg) is basically preferred for the processing of traditional dry-cured products. In addition it is widely supposed that increasing age at slaughter improves the palatability of pork (Candek-Potokar et al. 1998). However, in order to assess the usability of such carcasses on present-day hogs, detailed knowledge about leanness, sizes and weights of cuts as well as meat quality in different parts of the carcass is essential.

Objectives

It was the aim of the present investigation to contribute objective data on the changes concerning carcass composition, weight of typical joints and meat quality in the course of a pro-longed fattening period up to live weights of 110, 135 and 160 kg. Furthermore the effects of gender and fattening intensity should be studied.

Methodology

A total of 123 crossbred pigs (Piétrain x Landrace, MHS-negative) were allocated to a 3 x 2 x 2 factorial experiment involving three live weights (110, 135, 160 kg), two genders (castrated males, females) and two fattening intensities (high, intermediate). Pigs were housed in straw-littered double-pens. In the growing period (30-80 kg live weight) all animals had free access to the feed. The diet for the finishing period (80 kg to the respective end of fattening) contained less protein and was different in the energy content according to the respective fattening intensity (Table 1). Females received the feed *ad* *libitum* and castrates were fed at a level corresponding to the average feed intake of the gilts.

The animals were slaughtered in the abattoir of the Training and Research Centre after a two hours' lairage. Following electrical stunning and exsanguination while hanging carcasses were scalded (62°C for 5 min), eviscerated and split in the usual way before, approximately 50 min p.m., being placed in a chiller (at 2°C). 40 min p.m. the pH_1 (pH-STAR, Matthäus) was measured on *M. longissimus dorsi* and *M. semimembranosus* .

At 24 h p.m., after measuring pH_{24} and electrical $conductivity_{24}$ (LF-STAR – Matthäus) of *M. longissimus dorsi*, the right carcass side was cut between 13^{th} and 14^{th} rib to measure backfat thickness, fat and loin area. Afterwards the half carcass was dissected into primal cuts according to the "DLG cutting method" (Scheper & Scholz, 1985), and the samples needed for further investigations were removed (*M. longissimus dorsi*, *M. semimembranosus* and *M. triceps brachii*).

For estimating the lean meat content an extra formula based on the weight of 6 DLG cuts was calculated (R = 0.94, RSD = 1.3) using total dissection data of 338 pigs with carcass weights up to 120 kg.

L*, a*, b* were measured 24 h p.m. (MINOLTA CR 300, light source: D65) after a 10-min blooming period. Additionally the total pigment concentration was determined (Hornsey, 1956).

The intramuscular content of water, protein, and fat was estimated by using Near-Infra-Red spectroscopy. Reference values of intramuscular fat were determined without a previous HCl treatment.

Drip loss was calculated as the proportionate weight loss of 2.5 cm thick slices hanging in narrow plastic containers for 24 hours (24-48 h p.m.) at 2 °C. These samples were subsequently used for cooking loss determination. Each slice was packed in a polyethylene bag and cooked in a pre-heated (75 °C) streaming water-bath. As soon as internal meat temperature had reached 75 °C (50-60 min) the samples were taken out, cooled down in tap water and reweighed. After storage overnight (4 °C) the samples were utilized for shear force measurements eventually. From each slice 6 strips with a cross-section of 1 x 1 cm were excised parallel to the muscle fibres and sheared using an Instron texture analyzer equipped with a Warner-Bratzler shear (Freudenreich and Augustini, 2000).

Samples to be grilled for shear force measurement (*M. long. dorsi*, 2^{nd} *lumbar vertebra*) and sensory evaluation (*M. long. dorsi, 4^{th} lumbar vertebra*) were cut out 72 h p.m., vacuum-packed and stored at –20 °C until further processing. Samples were thawed at 4 °C for 24 hours before heating. Then they were trimmed, sectioned in 2.5 cm thick chops, covered with tin foil and heated in an iron plate contact grill to an internal temperature of 75°C. In case of shear force measurement the samples were cooled down over-night and then treated in the same way as described above.

Sensory evaluation was carried out on hot samples. From each slice 6 cubes (about 2x2x2 cm) were cut out and presented to the six panellists sitting in single booths. The attributes rated according to 6-point scales were tenderness (1 = very tough, 6 = very tender), juiciness (1 = very dry, 6 = very juicy), and flavour (1 = very poor, 6 = very good).

The effects of weight, sex and fattening intensity and the interaction of sex with weight class were tested with a General Linear Model (Proc GLM of SAS 9.1). If main or interaction effects were significant with $P<0.05$, between-class differences were tested with least-squares means. As the effect of fattening intensity was generally small and only rarely significant (e.g. some carcass traits), the respective results will not be presented in this paper.

Results & Discussion

The data of growth and carcass composition are shown in Table 2. Fattening the pigs up to a live weight of 160 kg instead of 110 kg increases the average age at slaughter by 55 days. There is no significant difference between the weight classes with respect to the daily gain, and the usual differences between castrates and females become smaller with increasing weight. As expected the feed efficiency of the whole fattening period deteriorates considerably with every stage of live weight and the inferiority of the castrates is most distinctive in the highest class. The average *M. longissimus* area increases from 55.5 to 70.4 cm^2 so that, in particular in case of the gilts (73 cm^2), the pork chops reach a size which might not be accepted by consumers. While the lean meat content of castrates and females, respectively, diminishes between the lowest and highest weight class by 3 and 4.1 percentage points, respectively, the back fat thickness increases from 13.0 to 19.7 mm and from 8.0 to 17.6 mm, respectively. This shift in carcass composition corresponds with the results of Bellof (1991) and Kuhn et al. (1997) obtained for pigs (up to 160 kg) of other breeds. Considering that the meat of heavy pigs is predominately used for dry products, the thicker backfat is rather desired.

In Table 3 the weight dependent shift of the most important primal cuts is expressed as a percentage of side weight. With increasing live weight there is generally a small tendency to a lower proportion of various cuts having a high lean meat content. That concerns especially the ham, the loin, the neck, and the tenderloin. As gilts are basically leaner than barrows, these cuts are represented in female carcasses to a higher percentage. This result could be expected, but the sex dependent differences become smaller with increasing live weight. The adipose layer on the back and the ventral parts of the belly grow more intensive than the leaner cuts mentioned above. Thus the backfat proportion in the carcass of castrates and females increases between 110 and 160 kg by 20 and 35 %, respectively, whereas the loin proportion decreases by 1.5 and 4.8 %, respectively.

Meat quality characteristics for the three muscles (*M. longissimus dorsi* - LD, *M. semimembranosus* - SM, *M. triceps brachii* - TB) are only presented with respect to weight class effects (Table 4). With the exception of electrical conductivity, where the value for LD in the 160 kg group is a little higher, which is possibly caused by a slower chilling of the heavy carcasses, no significant influence of live weight has been found in traits directly connected with the PSE status (pH, drip loss). The brightness (L*) shows a general tendency to lower values with increasing live weight, whereas the colour becomes clearly more red (a*). This finding, which is basically in line with the results of Berry et al. (1970) and Martin et al. (1980), cannot be interpreted as a DFD effect because of the unaltered pH 24 h p.m. The reason has to be sought in the significant weight dependent increase of total pigment concentrations which occurs on different levels in every muscle. The cooking loss and the water content show a small decrease with higher live weights. But the intramuscular fat content is only in case of the TB slightly affected. This is in contrast to Candek-Potokar et al. (1998), who found a clear rise of IMF when raising pigs up to 130 kg live weight. Not affected is the shear force in LD and SM. However in the SM the values markedly diminish from 110 to 130 and 160 kg live weight, which seems rather unexplainable. Concerning the sensory evaluation, there is only a small deterioration from the medium to the high weight class, being significant only in juiciness.

Conclusions

Increasing the live weight at slaughter of MHS negative Piétrain x Landrace crossbreds from 110 to 160 kg

- does not affect the daily gain but deteriorates the feed efficiency considerably
- diminishes the lean meat content by 3-4 percentage points
- decreases the percentage of lean cuts (loin, ham, neck) slightly, and considerably increases the proportion of adipose tissue on the back and the belly
- does not affect meat quality traits connected with the PSE and DFD problem
- causes a darker and more red meat colour by elevated pigment concentration
- reduces the water content marginally, but does not clearly affect intramuscular fat
- does not influence shear force but slightly impairs sensory quality

Thus, raising heavy pigs only makes sense for the processing of dry cured products but not for the fresh meat market.

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Tables and Figures

Table 1. Ingredients and composition of growing and finishing diets

	Growing diet 30 to 80 kg	Finishing diet 80 kg until end of fattening	
Ingredient (%)		High intensity	Moderate intensity
Barley	48.0	50.0	78.4
Wheat	30.8	36.4	-
Wheat bran	-	-	10.0
Soybean meal (48 % Cr. Prot.)	17.0	11.0	9.0
Acid	0.7	0.5	0.5
Minerals	2.6	2,1	2.1
Soybean oil	0.9	-	-
Composition (%)			
Crude protein	18.5	14.9	13.9
Lysine	1.1	7.4	7.2
Crude fibre	3.9	36.0	51.0
Crude fat	2.8	2.2	2.7
Metabol. energy (MJ/kg)	13.4	12.8	12.0

Table 2:Least square means for growth and carcass data by live weight class (LWC) and sex (castrates/ females)

		Live weight class			Overall effect[4]	
	Sex	110 kg n[1] = 19/17	135 kg n[1] = 27/27	160 kg n[1] = 17/16	LWC	Sex
Age at slaughter (d)	Castrates Females	176^{A} 181^{A}	201^{B} 210^{B}	230^{C} 235^{C}	***	*
Daily gain (g/d)	Castrates Females	949^{+} 846^{+}	898 862	882 851	ns	***
Feed efficiency[2]	Castrates Females	2.69^{A} 2.65^{A}	2.87^{B} 2.84^{A}	3.14^{C} 3.05^{B}	***	ns
Carcass weight (kg)	Castrates Females	89.7^{A} 88.1^{A}	108.4^{B} 109.8^{B}	130.5^{C} 129.0^{C}	***	ns
Longissimus area (cm^2)	Castrates Females	52.9^{A} 58.3^{A}	63.5^{B} 66.7^{B}	67.9^{B} 73.1^{C}	***	***
Backfat thickness[3] (mm)	Castrates Females	13.0^{A+} 8.0^{A+}	16.8^{B+} 12.9^{B+}	19.7^{B} 17.6^{C}	***	***
Lean content (%)	Castrates Females	57.1^{A+} 61.2^{A+}	56.4^{A+} 59.4^{A+}	54.1^{B+} 57.0^{B+}	***	***

[1]) Number of castrates/females within the respective weight class

[2]) kg feed/kg weight gain

[3]) Smallest backfat thickness on the cross-sectional area at13th/14th rib

[4]) ns = not significant, * = <0.05; ** = <0.01; *** = < 0.001

[A,B,C]) Only LSM estimates with different superscripts within a row differ, $P < 0.05$

[+]) Only LSM estimates with the superscript "+" (within LWC) differ between castrates and females,

$P < 0.05$

Table 3: Least square means for proportion of cuts[1] in % of the carcass half [2] by live weight class and sex

Trait	Sex	Live weight class			Overall effect[4]	
		110 kg n[3] = 19/17	135 kg n[3] = 27/27	160 kg n[3] = 17/16	LWC	Sex
Carcass side[2] (kg)	Castrates Females	43.0^{A} 42.3^{A}	51.8^{B} 52.5^{B}	62.4^{C} 61.7^{C}	***	ns
Ham (%)	Castrates Females	26.4 26.9	26.0^{+} 26.7^{+}	26.1 26.1	*	**
Loin (%)	Castrates Females	13.4^{+} 14.5^{+}	13.6 14.1	13.2 13.8	ns	***
Neck (%)	Castrates Females	7.5 7.8	7.6 7.7	7.3 7.5	*	*
Shoulder (%)	Castrates Females	13.6 13.6	13.6 13.5	13.6 13.6	ns	ns
Belly (%)	Castrates Females	10.1 9.5	10.4^{+} 9.9^{+}	10.2 10.2	*	**
Tenderloin (%)	Castrates Females	1.5^{+} 1.6^{+}	1.5 1.6	1.4 1.5	**	***
Backfat (%)	Castrates Females	4.3^{A+} 3.4^{A+}	4.7^{AB+} 3.9^{A+}	5.2^{B} 4.6^{B}	***	***
Ventral parts of belly (%)	Castrates Females	3.4 3.4^{A}	3.7 3.7^{AB}	3.9 4.1^{B}	***	ns

[1]) According to DLG cutting method
[2]) According to EU reference cutting
[3]) Number of castrates/females within the respective weight class
[4]) Significance level for the effects of live weight class (LWC) and sex
ns = not significant, * = <0,05; ** = <0,01; *** = < 0,001
[A,B,C]) Only LSM estimates with different superscripts within a row differ, $P < 0.05$
[+]) Only LSM estimates with the superscript "+" (within LWC) differ between castrates and females, $P < 0.05$

Table 4: Least square means for meat quality traits in *M. longissimus dorsi*, *M. semimembranosus* and *M. triceps brachii* by weight class

		Live weight class			Overall effect[1]
	Muscle	110 kg n = 36	135 kg n = 54	160 kg n= 33	LWC
pH_1	LD	6.45	6.53	6.45	ns
	SM	6.65	6.68	6.66	ns
pH_{24}	LD	5.45	5.43	5.43	ns
	SM	5.62	5.62	5.58	ns
Electrical conductivity$_{24}$	LD	3.6^{A}	3.7^{A}	4.8^{B}	***
	SM	2.9	2.9	2.9	ns
L^*_{24}	LD	54.0^{A}	51.9^{B}	52.5^{AB}	**
	SM	50.6	51.7	50.3	ns
	TB	45.9^{A}	44.0^{B}	42.2^{C}	***
a^*_{24}	LD	7.3^{A}	7.3^{A}	8.2^{B}	**
	SM	9.1^{A}	9.9^{AB}	10.8^{B}	***
	TB	14.1^{A}	13.8^{A}	15.7^{B}	***
b^*_{24}	LD	4.8	4.6	5.1	ns
	SM	5.6^{A}	6.2^{B}	5.9^{AB}	*
	TB	6.4^{A}	5.7^{B}	6.0^{AB}	*
Total pigment (mg Haemin/100g)	LD	3.4^{A}	3.7^{A}	4.0^{B}	***
	SM	4.0^{A}	4.4^{B}	4.7^{B}	***
	LD	8.5^{A}	9.4^{B}	10.3^{C}	***
Drip loss (%)	LD	1.4	1.2	1.7	ns
	SM	1.6	1.3	1.7	ns
	TB	0.6	0.6	0.7	ns
Cooking loss (%)	LD	33.6^{A}	32.6^{A}	31.5^{B}	***
	SM	33.4^{A}	33.5^{A}	32.3^{B}	**
	TB	34.3	33.5	33.1	ns
Water content (%)	LD	74.4^{A}	74.1^{B}	73.6^{C}	***
	SM	73.7^{A}	73.4^{A}	72.9^{B}	***
	TB	75.6^{A}	75.2^{B}	75.0^{B}	***
Fat content (%)	LD	1.63	1.45	1.57	ns
	SM	3.05	3.06	3.47	ns
	TB	1.78^{A}	2.08^{AB}	2.10^{B}	*
Shear force – after boiling (N)	LD	48.6	50.1	49.4	ns
	SM	50.5^{A}	41.7^{B}	39.7^{B}	***
	TB	47.7	48.2	49.2	ns
Shear force – after grilling (N)	LD	32,8	29,8	32,2	ns
Juiciness score[2]	LD	3.04^{AB}	3.37^{A}	2.87^{B}	**
Tenderness score[2]	LD	3.56	3.75	346	ns
Flavour score[2]	LD	3.41	3.44	3.15	ns

1) ns = not significant, * = <0.05; ** = <0.01; *** = < 0.001

2) 6-point scale, 6 = best rating, 1 = worst rating

A,B,C) Only LSM estimates with different superscripts within a row differ, $P < 0.05$