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EFFECTS OF CARCASS WEIGHT ON QUALITY OF MAJOR CARCASS CUTS, THEIR COMPOSITION, AND MEAT IN LITHUANIAN SLAUGHTER PIG POPULATION

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The cut out and dissection data from 137 carcasses of the Lithuanian slaughter pig population were used to study the impact of carcass weight on the quality of primal carcass cuts, their composition, and meat. The ratio of gilts to barrows, used in the experiment, was 1:1, and the carcass hot weight was recorded within 45 min post mortem in four groups, covering carcass weight range: under 65 kg, 65.1-76.9 kg, 77.0-85.9 kg, 86.0 kg and over. The study indicated that when the carcass weight increased there were increases in the proportion of hams, bellies and tenderloins ($p<0.05$) and decreases in the proportions of carcass parts of lower value ($p<0.001$). The increase in the carcass weight decreased the proportion of bones in ham, loin, shoulder ($p<0.001$) and belly ($p=0.062$). The highest proportions of lean tissues in the hams, loins, shoulders and bellies were obtained in the group of 77.0-85.9 kg carcass weight. Meat composition was not affected by the carcass weight. CIE a colour score increased ($p<0.05$) from 86 kg weight, whereas CIE L* slightly tended ($p=0.064$) to decrease from 77.0-85.9 kg and over.*

Key words: carcass, lean, meat, pigs, weight

INTRODUCTION

In Lithuania and other countries pig production made great strides to reduce the fat content and improve the leanness of pork. Knowledge of pig carcass composition and development of body composition during growth are important to improve the efficiency of the production system and to increase the profit on present pig production selected for lean tissue (De Lange *et al*., 2003; Whittemore *et al*., 2003; Landgraf *et al*., 2006). Decreased carcass fatness plays a great role in increasing primal cuts and subprimal cut yields and carcass composition than muscling even in lean, heavily muscled carcasses (Pringle and Williams, 2001). The conformation of the carcass is an important commercial factor because it indicates the yield of different cuts of meats (McFarlane *et al*., 2005). Numerous investigations have been concerned with the development of bone, muscle, fat tissue and chemical composition of pigs (Shields *et al*., 1983;

Pringle and Williams, 2001; Schinckel *et al*., 2001; De Lange *et al*., 2003; Barea *et al*., 2006; Kloareg *et al*., 2006; Greenfield *et al*., 2009). Carcass weight is a good indicator of major differences in the weight of lean meat and fat. An increase in slaughter weight impairs growth performance but might improve some carcass characteristics (Latorre *et al*., 2008; Lo Fiego *et al*., 2005) and meat traits (Lebret *et al*., Virgili *et al*., 2003), which would be beneficial for pork industry and consumers. Choice of slaughter weight depends upon the proper description of pig growth performance, carcass conformation with regard to the characteristics of the edible tissues, and development of carcass value during growth. However, total carcass weight does not provide any information on the proportion of each cut by weight and measurements of fat, and muscle thickness at the grading site does not allow to determine the fat content of the ham, shoulder and belly in an optimal way (Marcoux *et al*., 2007). The objectives of the present study were to examine the development of the main carcass cuts and their dissected components, and the remaining cuts with respect to carcass weight.

MATERIAL AND METHODS

Design of the experiment

One hundred thirty-seven pig carcasses were selected in the abattoir "Utenos mesa" in Lithuania. The ratio of gilts to barrows was 1:1, and the carcass hot weight was recorded within 45 min *post mortem* in four groups, covering carcass weight range: under 65 kg, 65.1-76.9 kg, 77.0-85.9 kg and 86.0 kg and over. Carcass weight included head, skin and legs without viscera, internal organs, flare fat, kidneys, diaphragm, genitals and tail. Selection of the carcasses was based on the backfat thickness measured on the left carcass side at the site "Fat_2" between the third and fourth from the last rib 60 mm off the dorsal midline within carcasses of 50-110 kg weight. The carcasses according to their measurements were selected in three backfat thickness categories (<13, 13.0 to 20.9, and ≥21 mm). Distribution of the selected carcasses by backfat thickness and weight is shown in Table 1. The average carcass weight and backfat thickness of the selected carcasses were, respectively 75.21 kg and 16.73 mm. These groups were selected in order to cover the main market types. No genetic information was collected on the selected carcasses.

Table 1. Distribution of selected carcasses by their backfat thickness and weight

	Warm carcass weight (kg)			
	≤65.0	65.1-77.0	77.1-86.0	≥86.1
Total number of carcasses	38	25	36	38
Backfat thickness (mm):				
<13 mm	19	9	11	5
13.0-20.9 mm	15	6	16	17
≥21 mm	4	10	9	16

On-line evaluation and dissection

Backfat thickness and lean meat content were measured by one operator using optical device grading - probe with Fat-o-Meat'er S70 (FOM). The cold left side of each selected carcass was jointed at 24 h after slaughter. Both major four parts (ham, shoulder, loin and belly), that contained more than 75% of carcass lean meat content, and the rest cuts (head with cheek, neck, jawl, legs, cuts from ventral part) were weighed. Four major cuts were dissected into tissues (muscle, intermuscular fat, fat with skin, cartilages and bones) using the standard procedure described by Walstra and Merkus (1995).

Meat quality measurements

Technological meat quality was determined after 48 h post mortem on the samples of *M. longissimus dorsi* (LD) taken at the last rib and backwards. Ultimat*et al*., 2004). Defrosted samples were also analysed for meat chemical content. Crude protein was determined by the Kjeldahl method, crude ash and ether extract after the hydrolysis of intramuscular fat were determined according to the standard methods described in AOAC: (Official Methods of Analysis of the Association of Official Analytical Chemists, 1995).

Statistical analyses

The data were subjected to the analysis of variance (ANOVA). Tukey's significance tests were used to ascertain the existence of significant differences between the traits. Significance was determined at $p<0.05$, but differences of $0.05 \le p<0.10$ would be considered as trends. All analyses were performed in MINITAB 15.

RESULTS

Weight group affected carcass traits. Fat and muscle thickness increased linearly with warm carcass weight increase (Table 2). Backfat thickness at the point of Fat1 increased by 1.10, 0.32 and 1.91 mm, respectively, for each 10-kg increase in weight of warm carcass above 65 kg ($p<0.05$). Yet higher increase of the fat layer, affected by the increase in carcass weight, was detected at the point of Fat2 ($p<0.01$). Increase in carcass weight also resulted in an increase in muscle depth ($p<0.001$). The highest lean meat content, detected by an optical grading probe with Fat-o-Meat'er S70 (FOM) was for carcasses of 77.0-85.9 kg weight. The predicted weights of the main four cuts are shown in Table 3. The weight of the trimmed hams, loins, shoulders, tenderloins and bellies increased significantly ($p<0.001$) with the increased carcass weight. The increase in carcass weight up, to but not over 86 kg, increased the proportion of hams and tenderloins ($p<0.05$). However, the increase in the proportion of loin and shoulder was insignificant. Also, the increase in carcass weight increased the proportions of belly and decreased the proportions of carcass parts of lower value ($p<0.001$).

Table 2. Characteristics of dissected carcasses

Variables	Warm carcass weight groups				P value
	≤65.0	65.1-77.0	77.1-86.0	≥86.1	
Weight of warm carcass (kg)	61.3±3.03	71.2±3.43	82.1±2.82	91.1±4.54	<0.001
Fat1 (mm)	17.84±5.98	19.56±5.99	19.88±4.31	21.79±4.81	0.016
Fat2 (mm)	15.00±5.74	16.68±5.71	16.72±4.51	19.05±4.29	0.008
Muscle depth (mm)	48.37±5.89	50.80±6.08	56.97±6.01	57.92±4.27	<0.001
Lean meat content % (FOM)	55.04±5.94	54.54±6.27	56.32±5.04	54.98±4.37	<0.001

Table 3. Developmental change of the main carcass parts during the growth of carcass weight

Variables		Warm carcass weight (kg)				P value
		≤65.0	65.1-77.0	77.1-86.0	≥86.1	
Weight of left half of carcass kg		30.22±1.57	35.27±2.02	40.31±1.69	44.92±2.63	<0.001
Ham	kg	7.57±0.51	8.74±0.55	10.23±0.46	11.02±0.75	<0.001
	%	25.06±1.38	24.80±1.29	25.39±1.15	24.56±1.22	0.036
Loin	kg	4.97±0.51	5.85±0.56	6.81±0.54	7.62±0.52	<0.001
	%	16.45±1.15	16.58±1.08	16.90±1.09	16.97±0.93	0.115
Shoulder	kg	3.88±0.29	4.47±0.41	5.30±0.33	5.88±0.29	<0.001
	%	12.87±0.86	12.68±0.87	13.16±0.68	13.11±0.70	0.066
Belly	kg	2.88±0.31	3.50±0.32	4.13±0.40	4.59±0.44	<0.001
	%	9.54±0.81	9.95±0.80	10.26±0.89	10.22±0.88	0.001
Tenderloin	kg	0.43±0.05	0.51±0.07	0.61±0.06	0.63±0.07	<0.001
	%	1.42±0.19	1.45±0.20	1.52±0.13	1.40±0.15	0.014
Rest parts of carcass	kg	10.52±0.75	11.87±0.82	13.24±0.92	15.20±1.53	<0.001
	%	34.79±1.53	33.62±2.34	32.81±1.45	33.80±1.87	<0.001

The proportion of head with cheek decreased ($p<0.001$), but the proportion of cuts from the ventral carcass parts increased ($p<0.05$) alongside with carcass weight increase (Table 4). The proportion of shanks and feet decreased at carcass weight of 77 kg and over. Weights and proportions of the dissected components from the main carcass cuts are presented in Table 5. The increase in carcass weight decreased the proportion of bones in ham, loin, shoulder ($p<0.001$) and belly ($p=0.062$). The lean tissue in the ham showed its highest weight increase between the 65.1-76.9 and 77.0-85.9 kg carcass groups, whereas the proportion of lean tissue in the ham increased extremely between the groups of carcasses under 65 kg and 65.1-76.9 kg. Moreover, the lean tissue in the loin, shoulder and belly showed the highest weight and proportion in the group of 77.0-85.9 kg carcasses. However, the increase in carcass weight increased the proportion of fat in the shoulder and belly ($p<0.05$). The estimates of the *m*. *longisimus dorsi* traits, presented in Table 6, did not show carcass weight effect on proximate composition. With respect to colour measurements, only CIE a* colour score of meat redness was affected by the carcass weight which increased ($p<0.05$) from 86 kg weight, whereas CIE L* slightly tended ($p=0.064$) to decrease from the third i.e. 77.0-85.9 kg weight group.

Table 4. Developmental change of the cuts of lower value during the growth of carcass weight

Variables		Warm carcass weight (kg)				P value
		≤ 65.0 (n=38)	65.1-77.0 (n=25)	77.1-86.0 (n=36)	≥86.1 (n=38)	
Head with cheek	kg	2.44±0.31	2.67±0.23	2.94±0.16	3.28±0.28	<0.001
	%	8.08±0.88	7.60±0.56	7.30±0.48	7.32±0.50	<0.001
Neck	kg	2.95±0.27	3.41±0.27	3.86±0.69	4.35±0.33	<0.001
	%	9.77±0.77	9.69±0.61	9.54±1.62	9.68±0.55	0.794
Jawl	kg	0.90±0.20	1.08±0.23	1.09±0.27	1.33±0.26	<0.001
	%	2.96±0.60	3.07±0.64	2.72±0.71	2.96±0.57	0.149
Shanks + feet	kg	2.51±0.22	2.79±0.20	3.04±0.23	3.38±0.25	<0.001
	%	8.33±0.70	8.44±2.27	7.56±0.59	7.81±1.72	0.037
Cuts from ventral parts	kg	1.68±0.25	2.03±0.18	2.29±0.28	2.71±0.25	<0.001
	%	5.57±0.73	5.79±0.59	5.68±0.60	6.03±0.78	0.031

Table 5. Developmental change of the dissected components of the main cuts during the growth of carcass weight

Variables		Warm carcass weight (kg)				P value
		≤65.0 (n=38)	65.1-77.0 (n=25)	77.1-86.0 (n=36)	≥86.1 (n=38)	
Ham						
Muscles	kg	5.24±0.96	6.10±0.75	7.31±0.61	7.67±0.96	<0.001
	%	67.73±14.62	69.65±6.02	71.39±3.98	69.40±4.23	0.350
Fat	kg	1.63±0.67	1.89±0.45	2.07±0.36	2.46±0.48	<0.001
	%	21.86±10.57	21.84±5.73	20.35±3.82	22.38±4.14	0.610
Bones	kg	0.69±0.07	0.74±0.05	0.84±0.07	0.89±0.09	<0.001
	%	9.22±1.04	8.56±0.60	8.31±0.80	8.24±0.89	<0.001

cont. Table 5.

Loin						
Muscle	kg	2.82±0.34	3.27±0.49	4.01±0.54	4.22±0.43	<0.001
	%	57.33±8.53	56.22±9.07	58.81±6.42	55.68±6.32	0.319
Fat	kg	1.45±0.63	1.79±0.07	1.93±0.45	2.45±0.58	<0.001
	%	19.36±9.11	20.68±7.90	18.85±4.95	22.16±5.82	0.186
Bones	kg	0.70±0.10	0.79±0.12	0.88±0.12	0.94±0.14	<0.001
	%	9.36±1.45	9.09±1.23	8.63±1.22	8.57±1.33	0.031
Shoulder						
Muscles	kg	2.56±0.27	2.92±0.40	3.55±0.33	3.80±0.38	<0.001
	%	66.03±5.32	65.15±5.36	66.96±4.17	63.91±0.07	0.128
Fat	kg	0.90±0.23	1.09±0.23	1.21±0.22	1.51±0.32	<0.001
	%	23.17±5.39	24.50±5.10	22.89±4.06	25.74±4.73	0.046
Bones	kg	0.42±0.05	0.46±0.04	0.54±0.07	0.57±0.05	<0.001
	%	10.93±1.31	10.45±1.03	10.26±1.16	9.76±0.75	<0.001
Belly						
Muscles	kg	1.62±0.26	1.92±0.37	2.36±0.37	2.37±0.38	<0.001
	%	56.82±9.43	54.80±9.80	57.07±6.69	51.71±7.21	0.020
Fat	kg	1.04±0.37	1.31±0.38	1.46±0.33	1.89±0.40	<0.001
	%	35.54±0.23	37.44±10.27	35.33±7.25	41.05±7.53	0.019
Bones	kg	0.23±0.04	0.27±0.05	0.31±0.05	0.33±0.05	<0.001
	%	8.15±1.73	7.72±1.51	7.68±1.00	7.30±1.09	0.062

Table 6. Effects of carcass weight on meat quality characteristics and proximate composition

Variables	Warm carcass weight (kg)				P value
	≤65.0	65.1-77.0	77.1-86.0	≥86.1	
pH ultimate	5.51±0.08	5.52±0.09	5.54±0.11	5.51±0.08	0.894
Colour L	56.11±2.02	57.85±1.97	55.65±1.23	55.50±1.99	0.064
a*	13.89±1.37	13.18±0.94	13.40±1.35	14.79±0.93	0.026
b*	7.11±1.90	7.58±0.99	6.81±1.39	7.36±1.65	0.814
Drip loss, %	5.24±2.03	5.82±2.97	5.00±1.75	5.51±0.82	0.870
Thawing loss, %	11.97±3.15	12.54±3.70	11.82±2.46	13.47±2.67	0.616
Dry matter, %	27.59±0.73	27.08±0.94	27.21±1.38	27.41±0.71	0.609
Protein, %	24.48±0.68	23.89±0.94	24.36±1.60	24.18±0.97	0.611
Intramuscular fat, %	2.03±0.82	2.14±0.65	1.80±0.39	2.14±0.69	0.766
Ash, %	1.04±0.04	1.01±0.08	1.03±0.06	1.04±0.06	0.703

DISCUSSION

Increasing carcass weight is one method of increasing the output and efficiency of meat for the producer and processor. The consumers demand leaner meat, but traditionally increasing carcass weight was associated with increases in carcass fatness. However, due to the changed genetic material in Lithuanian pig production, carcass composition has also changed. As revealed in other studies (Marcoux *et al*., 2007), the total value of the carcass is affected by the individual contribution of each cut (loin, ham, belly and shoulder) and these individual contributions are dependent on their monetary value, their weight and leanness, and need to undertake a serious examination of the carcass grading. It has been observed (Olsen *et al*., 2007) that single measurement of fat and muscle thickness contains maximum information, but additional information from supplementary measurements of anatomical characteristics can improve the accuracy of pig carcass classification. Our previous study showed that the carcass lean content predicted by dissection was 1.1 – 2.6% higher than that measured by FOM (Ribikauskiene *et al*., 2009). The lowest difference of lean meat content was found in heavy carcasses and in carcasses with lower backfat thickness. To place the premiums only on lower backfat thickness and greater loin muscle depth, with the aim of increasing the size of chop is questionable, since it does not guarantee a response in terms of an increase in the weight of the loin (Marcoux *et al*., 2007). As it was expected, in our study the predicted weights of the main cuts showed a significant increase weight of the trimmed hams, loins, shoulders, tenderloins and bellies. This is in agreement with Landgraf *et al*. (2006) who showed a developmental change of primal cuts at different carcass weights. Although, the increase in the proportion of loin and shoulder in the present study was insignificant, the proportions of total rest carcass parts of lower value decreased. As observed by other researchers (Beattie *et al*., 1999; Senčić *et al*., 2005; Stupka *et al*., 2008), increasing carcass weight might also have decreased the lean content. In the present study the increase in carcass weight significantly decreased the proportion of lean only in the belly. For all given weight classes, the proportions of lean tissue in the ham, shoulder and belly were higher compared to the data presented by Kosovac *et al*. (2009). While the proportion of fat in the shoulder and belly in this study increased, it must be noted that the value of the fat content in the carcass differs depending on the anatomical location. The belly which could be processed into bacon in many countries has a high commercial value (Marcoux *et al*., 2007). As it was reported in other studies (Correa *et al*., 2006), no evidence was found that increasing slaughter weight detracts from carcass characteristics and meat quality. In contrast to the results obtained in this study Beattie *et al*. (1999) found a reduction in ultimate pH and cooking loss with increasing carcass weight.

The higher a* value affected by increased weight in the present study was in accordance with Piao *et al*. (2004), but in contrast with the observations of Čandek-Potokar *et al*. (1998) who found no effect of increased weight.

In conclusion, the results of this study have confirmed that the accurate prediction of lean yield using an optical grading probe Fat-o-Meat'er S70 (FOM) provides relevant information and corresponds to outcut and dissection data. The results also suggest that the most acceptable carcass weight for current Lithuanian slaughter pig population could be 77-86 kg without compromising carcass and meat quality.

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EFEKTI MASE TRUPA NA KVALITET VELIKIH KOMADA MESA, NJIHOVOG SASTAVA I NA KVALITET MESA KOD ZAKLANIH SVINJA U LITVANIJI

RAZMAITE VIOLETA, RIBIKAUSKIENE DAIVA i STIMBIRYS A

SADRŽAJ

Podaci o komadima mesa i odrescima dobijeni od 137 zaklanih svinja litvanskog porekla korišćeni su u istraživanju uticaja mase trupa na kvalitet osnovnih delova trupa, njihovog sastava i kvaliteta mesa. Odnos nazimica i nerastova koji su korišćeni u eksperimentima je bio 1:1, a masa neohlađenih trupova je registrovana tokom 45 minuta *post mortem* u četiri grupe koje su obuhvatale sledeće kategorije trupova: ispod 65 kg, 65,1-76,9 kg, 77,0-85,9 kg, 86 kg i iznad te težine.

Rezultati ovih ispitivanja ukazuju da je masa trupa rasla u delovima potrbušine, šunke i slabinskog dela ($p<0,05$) i opadala u delovima trupa slabijeg kvaliteta ($p<0,001$). Povećanje mase trupa je smanjivalo količinu kostiju u šunci, slabinskom delu, ramenom delu ($p<0,001$) i potrbušini ($p=0,062$). Najveća količina krtine u šunci, slabinskom delu, ramenom delu i potrbušini je bila utvrđena u grupi sa masom trupova od 77,0 – 85,9 kg. Na sastav mesa nije uticala masa trupa. CIE a* vrednost boje je rasla ($p<0,05$) od 86 kg mase, a CIE L* boja ($P=0,064$) je opadala od 77,0-85,9 kg i kod većih masa.